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This is a second, extensively revised edition of the successful *Field Guide to Pests of Managed Forests in British Columbia* (1989) by K. Finck, P. Humphreys, and G. Hawkins. The 1989 edition has been a standard reference for ministry and university courses, and has been used extensively for field surveys and related work in British Columbia. Approximately 10,000 copies of the first edition were printed and distributed by the Canadian Forest Service and BC Ministry of Forests, and several hundred copies per year have been sold to the public through an agreement with Queen's Printer Publications. The Forest Practices Branch of the BC Ministry of Forests continues to receive numerous requests for copies and updates.

Several new developments in forest management practices and opportunities for investments in enhanced forest management treatments prompted the revision of the first edition. The first edition focused exclusively on damage to young trees. However, similar descriptions were needed to identify, in particular, bark beetles and wood decay of mature trees. Therefore, several supplementary descriptions were published by the ministry, and have been incorporated in the second edition.

A second major impetus for revisions was the development of the *Forest Practices Code Act of BC*. Most of the new forest health program approach was embodied in nine forest health guidebooks as recommended treatments and practices. These include management of root diseases, dwarf mistletoes, stem rusts and diseases of pines, general forest health incidence surveys, wood decays, bark beetles, insect defoliators, terminal weevils, and pests of young stands (under review). The code also incorporated an obligation for licensees who harvest timber to establish healthy, free-growing, young trees, based on damage criteria used to evaluate tree health at the time of the free-growing assessment. These developments re-confirmed the need for an updated, basic field identification manual as an essential reference for forest development plans, operational planning, development of prescriptions, and application of insect and disease treatments.

Another development that led to a new edition was the increased management of broadleaf tree species for commercial timber production, animal habitat, and other objectives. These tree species, including red alder *(Alnus)*, birch *(Betula* species), maple (Acer), and aspen and cottonwood *(Populus* species), are affected by many agents that must be monitored to ensure achievement of resource management objectives.

The major distinctive and useful feature of the first edition that has been retained is a description of each insect or disease on a single (two-sided) sheet that fits a standard six-ring field notebook. This format enables field staff to sort or organize sheets to cover damaging agents in their locality, and to insert forms and/or supplementary information.

Because of the emphasis on field use, the second edition also limits coverage to insects, diseases, abiotic damage, and animal damage that are significant in forest management, e.g., those agents that cause substantial damage, are frequently treated or managed, and/or are very common. Descriptions are also restricted to features that can be recognized while working in the forest.

Common names for insect pests and diseases were obtained from *Nomenclatura Insectorum Canadensium* (Benoit, 1985), and *Common Names for Tree Diseases in the Western United States and Western Canada* (Hawksworth et al., 1985), respectively.

Readers will notice that several deletions have been made from the first edition, such as keys and some other supplementary text, which were judged to be little-used or superfluous. Treatment methods or strategies have been excluded because this information often becomes obsolete quickly. For current recommended control or management techniques and strategies, readers should consult the *Forest Practices Code of BC* forest health guidebooks. These recommendations and procedures will be updated as needed.

The evolving nature and scope of forest management in British Columbia will no doubt require further revisions of this guide. In recent years, there has been wider appreciation that wildlife (animals), insects, mites, fungi, parasitic plants, and non-living (abiotic) elements are integral components of forest ecosystems, and perform many essential or valuable functions. In many instances, damaged or decayed trees are desirable attributes of managed forests because of their beneficial functions, such as reservoirs of mycorrhizal fungi, nesting and resting sites for animals, and sources of organic materials for maintaining soil fertility. The implementation of the *Forest Practices Code* means that we can expect to see greater use of silviculture systems that retain more older living trees, which are often affected by, or harbour, many damaging agents. Given these situations, the future challenge will be to ensure regeneration of healthy young forests.

HOW TO USE THIS GUIDE

The purpose of this field guide is to help field personnel identify damaging insects, diseases, and other agents. This guide is not intended to replace the specialized training required to become proficient in diagnosing all causes of damage to our forests; it was designed to help the user recognize general groups of damaging agents, important insects and fungi, animal activity, common abiotic agents, and the damage all of these can cause. Therefore, like the first edition, this guide describes only the more important agents that damage trees. If an agent that is causing damage is not described in this guide, consult the general texts listed in the References section, or contact District or Regional forest health specialists at BC Ministry of Forests or the Canadian Forestry Service.

This field guide is divided into two parts: Damage Agents of Coniferous Trees, and Damage Agents of Broadleaf Trees. In each part, there are four main sections: insects, diseases, abiotic injuries, and animal damage. Under each section, damaging agents are grouped according to the portion of the tree attacked, and are roughly ordered based on the extent of damage the agent causes and its frequency in BC forests.

THE FOLLOWING STEPS ARE SUGGESTED FOR IDENTIFICATION:

Use the photographs and descriptions in the guide to make tentative identification.

Distinguish between agents that cause similar damage by noting differences explained under the headings "Similar Damage" or "Can Be Confused With".

Use the guide's Host-Agent Index, which lists insects and diseases affecting each tree species according to the portion of the host affected.

Where needed, collect specimens to verify field identifications, and submit them to the Canadian Forest Service, using the Canada/BC Forest Insect and Disease Collection and Identification form (FS466).

The Appendices include the following aids:

- Host-Agent Index
- Specimen Collection and Shipment
- Glossary
- References
- Alphabetical Index

PART 1

DAMAGE AGENTS OF CONIFEROUS TREES IN BRITISH COLUMBIA

DAMAGE AGENTS OF CONIFEROUS TREES IN BRITISH COLUMBIA

Damage agents of coniferous trees in British Columbia have been studied extensively for over 30 years and damage caused by many of them has been managed for the last 20 years. Numerous economic studies and analyses have been conducted to estimate timber losses because of these damage agents. More recently, studies have been conducted to better understand the ecological context of the organisms.

Fundamental to investigations into forest damage is the ability to identify the organisms that create damage to forest trees. Further, we must be able to distinguish between organisms that may cause serious damage and those that pose an incidental threat.

Part 1 describes most insects, diseases, animals, and abiotic conditions that cause economic damage to commerically important coniferous trees in the province. Within each subsection, damage agents are ordered by the apparent extent of damage caused.

Introduction to Insects of Coniferous Trees

Insects cause substantial economic loss to British Columbia's forests. Insect outbreaks often occur sporadically and are characterized by rapid increases in population size and resulting damage. Accurate insect identification forms the foundation of treatments and management practices.

To facilitate identification, the insects discussed in this part are divided into the following categories: defoliators, sucking insects, and woody tissue feeders (includes most bark beetles). Separation of these three groups is based on feeding habits. Defoliators feed on foliage and buds with cutting and chewing mouth parts. Sucking insects have piercing and sucking mouth parts for removal of sap from needles, branches, or stems. Woody tissue feeders have similar mouth parts to defoliators, but feed instead on the outer sapwood of the main stem, branches, root collar, or roots, or the woody tissue within branch tips and leaders.

Larvae of most species in these categories are responsible for the vast majority of damage and are generally the most conspicuous life stage. Thus, larval description is usually emphasized.

The presence of larvae is generally restricted to a small portion of the year. Therefore, the observer must frequently base a diagnosis on the resulting feeding damage. Sucking insects and woody tissue feeders often cause fairly distinctive injury. Gouting, deformity, or chlorosis result from infestation by sucking insects. Woody tissue feeders create pitch nodules or tunnels in the wood, or destroy leaders and branch tips. Frequently, evidence of defoliators, such as frass, webbing, mined or clipped needles, and the overall appearance of the crown, is similar between species. The preferred host(s), pest range, and history of local epidemics should be considered when attempting to identify any insect pest, especially when insects are not present.

DEFOLIATORS

Defoliating insects can be extremely destructive. Trees of any age may be attacked. Larvae (caterpillars) of moths (Lepidoptera) and sawflies (Hymenoptera) are the most important defoliators of conifers. Defoliator damage may include mining of needles and buds during the early stages of larval development, followed by open feeding on the foliage. Needles may be entirely or partially consumed. Defoliation primarily results in reduced growth and lost volume with little resulting mortality. Volume loss can be significant, but is sometimes difficult to detect. Occasionally, severe defoliation occurs over several consecutive years, causing substantial damage.

Damage or signs indicating defoliator activity include: discolouration or loss of foliage, generally progressing from the top downward and from the branch tips inward; mined, chewed or clipped needles on the tree or accumulated on the ground; abundant webbing in the crown; accumulation of insect frass; and the presence of defoliating insects at various stages of development. Caterpillars, which may be smooth or hairy and have less than six pairs of leg-like appendages on the abdomen, are the larval stage of moths (*Lepidoptera*). They may vary in colouration or markings as they mature through several steps or instars. Sawfly larvae resemble caterpillars except they have six or more pairs of leg-like appendages on the abdomen.

Pupae are found on the host or in the litter layer. They are generally oblong to cylindrical, papery or leathery, and variable in colour from white or grey to dark brown. The pupal cases or "shells" are evidence that is left behind when the adult emerges. Adult flights may occur any time from spring to fall, depending upon the species. Eggs are minute. They can be found either singly or in clusters on the host or nearby vegetation.

Damage forecasts for defoliators are based on egg or larval sampling, mass rearing, or pheromone trapping. Climatic conditions and biological control factors make accurate population predictions difficult. Pesticides are occasionally used to reduce damage in severe outbreaks.

WESTERN SPRUCE BUDWORM

Choristoneura occidentalis (Freeman)

DISTRIBUTION

The western spruce budworm is found in the coast, montane, and Columbia forest types of southern BC, at 350 to 1460 m in elevation.

Fig 1. Western spruce budworm moth.

TREE SPECIES ATTACKED:

The host is primarily Douglas-fir, though spruce, western larch, and lodgepole pine are attacked occasionally. All ages of trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae are very small and light yellow-green. As they grow, larvae become brown with a dark brown head capsule, and four conspicuous, paired, ivory-coloured spots appear on each body segment. In the last instar, some larvae turn olive-brown. Full-grown western spruce budworms are 1.6 to 3.2 cm long. Larvae pass through six instars before they pupate.

The larvae pupate within webbed foliage from late June to mid-July. Pupae are dark reddish-brown and 1.2 to 1.6 cm long. The adult moth is mottled grey to rusty brown, with a wingspan of 2.4 to 3 cm long. The female moths lay eggs in masses on the underside of needles in a shingle-like pattern in August. The egg masses are bright green when laid, and translucent white when empty. The life cycle is completed in one year.

Initially, larvae mine the needles, buds, and new cones, and feed on current foliage after bud flush. Older larvae prefer current foliage but will feed on older foliage if current foliage is depleted. Feeding takes place from late April through June. The crowns of damaged trees appear reddish-brown from June to September. The initial symptoms of defoliation may be seen in tree tops and branch tips, where chewed needles accumulate in webbing.

DAMAGE:

Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.

SIMILAR DAMAGE:

Damage can be confused with other defoliators, such as early feeding by the tussock moth, or several species of cone worms. The prominent ivory–coloured spots on the western spruce budworm larvae are very distinctive. The different host species and provincial distribution distinguish the various species of budworm from each other.

Fig 2. Western spruce budworm damage to a Douglas-fir stand.

2-YEAR-CYCLE BUDWORM

Choristoneura biennis (Freeman)

DISTRIBUTION

The 2-year-cycle budworm is found in the subalpine and boreal forest types of the interior.

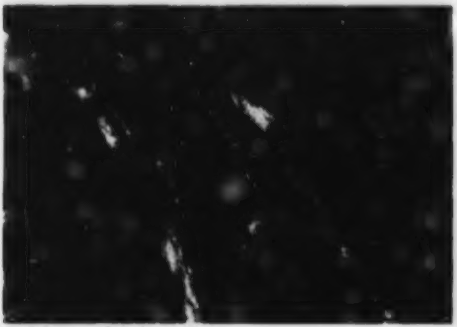


Fig 3. 2-year-cycle budworm pupa.

Fig 4. 2-year-cycle budworm egg mass after hatching.

TREE SPECIES ATTACKED:

The primary hosts are sub–alpine fir and the white spruce/Engelmann spruce complex. All ages of trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae are very small and light yellow-green. As they grow, larvae become brown with a dark brown head capsule. In the last instar, some larvae turn olive-brown. Larvae are 1.6 to 3.2 cm long. Larvae pass through six instars before they pupate.

The larvae pupate within webbed foliage from late June to mid-July. Pupae are dark reddish-brown and 1.2 to 1 6 cm long. The 2-year-cycle budworm moth is darker and slightly larger than the western spruce budworm. The female moths lay eggs in masses on the underside of needles in a shingle-like pattern in August. The egg masses are bright green when laid, and translucent white when empty. This budworm, as its name suggests, takes two years to complete its life cycle, with eggs laid primarily in even-numbered years.

Initially, larvae mine the needles, buds, and new cones, and feed on current foliage after bud flush. Older larvae prefer current foliage but will feed on older foliage if current foliage is depleted. Feeding on old foliage does not take place until the second spring. This is the year that damage is the heaviest. Feeding takes place from late April through June. The crowns of damaged trees appear reddish-brown from June to September. The initial symptoms of defoliation may be seen in tree tops and branch tips, where chewed needles accumulate in webbing.

DAMAGE:

Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.

SIMILAR DAMAGE:

Damage can be confused with other defoliators, such as early feeding by the tussock moth, or several species of cone worms. The different host species and provincial distribution distinguish the various species of budworm from each other.

EASTERN SPRUCE BUDWORM

Choristoneura fumiferana (Clemens)

DISTRIBUTION

The eastern spruce budworm is found in the boreal forests of north–eastern BC, at 350 to 1050 m in elevation.

Tree Species Attacked:

The primary hosts are sub–alpine fir and the white spruce/Engelmann spruce complex. All ages of trees are susceptible.

Insect Description & Damage Symptoms:

The eastern spruce budworm and the damage it causes appear very similar to the western spruce budworm and its damage (see photographs on pages 11-12). The two species are geographically separate.

Young larvae are very small and light yellow-green. As they grow, larvae become brown with a dark brown head capsule. In the last instar, some larvae turn olive-brown. The full-grown larvae vary in size, from 1.8 to 2.4 cm in length. Larvae pass through six instars before they pupate.

The larvae pupate within webbed foliage from late June to mid-July. Pupae are dark reddish-brown and 1.2 to 1.6 cm long. The eastern spruce budworm moth is smaller than the western and 2-year-cycle budworms, with a wingspan of about 2 cm. It is mottled grey to copper-brown in colour. The female moths lay eggs in masses on the underside of needles in a shingle-like pattern in August. The egg masses are bright green when laid, and translucent white when empty. The life cycle is completed in one year.

Initially, larvae mine the needles, buds, and new cones, and feed on current foliage after bud flush. Older larvae prefer current foliage but will feed on older foliage if current foliage is depleted. Feeding takes place from late April through June. The crowns of damaged trees appear reddish-brown from June to September. The initial symptoms of defoliation may be seen in tree tops and branch tips, where chewed needles accumulate in webbing.

DAMAGE:

Tree mortality can occur after several successive years of severe defoliation, particularly on immature or suppressed trees. Other damage includes top-kill (resulting in stem defects), reduced seed production due to damaged cones, and height and volume loss.

SIMILAR DAMAGE:

Damage can be confused with other defoliators, such as early feeding by the tussock moth, or several species of cone worms. The different host species and provincial distribution distinguish the various species of budworm from each other.

WESTERN BLACKHEADED BUDWORM

Acleris gloverana (Wlshm.)

DISTRIBUTION

Throughout BC except the PP biogeoclimatic zone. Occurs from 0 to 1400 m elevation. The most serious defoliation is found on the Queen Charlotte Islands and northern Vancouver Island.

Fig 5. Mature western blackheaded budworm larva and webbing.

TREE SPECIES ATTACKED:

Western hemlock and true firs are the preferred hosts, but spruce and Douglas-fir can also be fed upon. All ages are susceptible.

Fig 6. Western blackheaded budworm only partially consumes needles.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

When young, larvae are pale yellow-green with a brown to black head. With age, the larvae become bright to yellow-green with a brown to black head. Full grown larvae are about 1.8 cm long.

Visible defoliation occurs from late June to late July in the interior and from mid-July to mid-August on the coast. Needles of opening buds are usually only partially eaten and some are clipped off at the base and webbed together on the twigs. From a distance, the damaged stand has a reddish-brown hue. Current foliage is preferred, but older needles will be attacked during heavy infestations. Pupation takes place within webs spun in the twig foliage in late August to early September. Pupae are green to brown and 1.2 cm long.

Fig 7. Hemlock stand defoliated by western blackheaded budworm.

DAMAGE:

The western blackheaded budworm prefers to feed on the upper crowns of dominant and codominant trees. Trees can be completely defoliated from a heavy attack. This severe defoliation can result in growth reduction and predisposition to attacks from secondary organisms. Successive years of severe defoliation may result in tree mortality. Some second-growth hemlock stands that have been severely defoliated for two successive years have sustained greater than 10% mortality; 75% of the remaining trees have suffered an average of 8 m of top-kill.

SIMILAR DAMAGE:

Other defoliators, such as the western spruce budworm, cause similar damage. The yellow-green body without spots and the dark head capsule distinguish the blackheaded budworm.

Fig 9. Western blackheaded budworm initially feeds on current foliage.

Fig 8. Western blackheaded budworm often defoliates the upper crown first.

BUD MOTHS

Zeiraphera spp.

DISTRIBUTION

Throughout BC following the range of spruce and larch.

Fig 10. Bud moth larvae on larch needle clusters. Body colour varies.

TREE SPECIES ATTACKED:

All ages of spruce and larch are attacked, and occasionally true firs.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are up to 1.4 cm long when fully grown. Larval body colour is variable and may be any of the following: pale green, dirty white, pale yellow, or yellowish-green to purplish-brown. Light brown spots may be present on the back or side of the larvae. The heads are broad and black when young, but eventually turn brown. Larvae drop to the ground by August and pupate in the litter layer.

Fig 11. Bud moth feeding damage to larch needle cluster.

Bud moth larvae feed only on the current year's foliage. On spruce, the larvae attack recently flushed buds. Many larvae secure the bud cap to the bud with silk strands and feed on the new foliage under the shelter of the bud cap. This type of feeding is not conspicuous at first, but later in the season, most attacked buds will retain their caps while healthy buds will not. Larvae may create feeding shelters by chewing needles off at the base and attaching them to twigs. On larch, young larvae feed on developing needle clusters. Older larvae construct tube-like structures from needle clusters and webbed tunnels along the branch axis, or they may feed directly on needles.

Fig 12. Bud moth attack on true fir showing resultant leader damage.

DAMAGE:

Since bud moths feed on current growth only, damage is limited to growth reduction and distortion of crowns. In some cases, however, this damage is extensive, causing reduction in stand performance, especially in young plantations.

SIMILAR DAMAGE:

Moderate larch sawfly damage is similar, but the larvae are easily distinguished from each other. Larch casebearer damage may appear similar from a distance, but closer inspection will show mined needles, as opposed to the chewed needles of the bud moths. At a distance, bud moth damage could be confused with white pine weevil damage.

Fig 13. Frass on bud indicates bud moth feeding. Note retention of bud cap.

DOUGLAS-FIR TUSSOCK MOTH

Orgyia pseudotsugata (McD.)

DISTRIBUTION

Warm, dry areas of the southern interior and occasionally on the south coast, 350 to 1250 m elevation.

Fig 14. Distinctive mature larva of Douglas-fir tussock moth.

TREE SPECIES ATTACKED:

Principally Douglas-fir, but other species such as ponderosa pine and western larch are occasionally attacked if adjacent to infested Douglas-fir. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae emerge from egg masses in late May to early June. They are 0.3 cm in length, light to dark brown, and covered with fine hairs. Mature larvae reach 3.0 cm in length and have four yellow to tan, rust-tipped tussocks on their backs and red spots located on the upper surface of each of the next three segments. There is one dark-coloured, pencil-like tuft behind each side of the head and one on the posterior. The head is glossy black. The entire body is covered with hairs growing from small red nodes. A broken orange-yellow stripe runs along each side of the body. The larvae pupate in July to August, in greyish-brown, spindle-shaped, silken cocoons, which incorporate larval hairs. Pupae are found on foliage, branches, and boles of host trees.

Fig 15. Douglas-fir tussock moth often defoliates upper third of crown first.

Young larvae prefer current foliage, but mature larvae will consume older foliage. Silk threads will be evident, especially in tree tops. The upper third of the crown is defoliated first. Defoliation is most evident in late July to September when attacked trees initially turn reddish-brown, then greyish-purple.

Early in the outbreak cycle, defoliation is often first detected on large, open-grown Douglas-fir on rock outcrops or at the edge of open range.

DAMAGE:

The Douglas-fir tussock moth has the potential to cause significant mortality due to defoliation. In addition, top-kill, growth reduction, and secondary attacks by insects and fungi may follow severe defoliation.

SIMILAR DAMAGE:

Early damage and webbing in trees may be similar to that caused by the western spruce budworm. The larvae are very different, however, and the tussock moth voraciously consumes both new and old foliage as opposed to the primarily new foliage consumption by the budworm. Tussock moth infestations tend to be relatively small and localized near the edge of open range, whereas western spruce budworm infestations are more widespread.

Fig 16. Silk webbing produced in Douglas-fir tussock moth infestation.

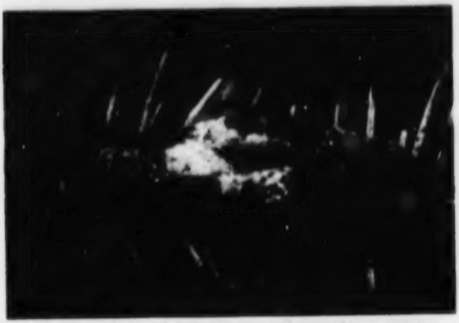


Fig 17. Douglas-fir tussock moth egg mass with young larvae emerging.

CONIFER SAWFLY

Neodiprion spp.

DISTRIBUTION

Coastal and interior wet belt areas of BC.

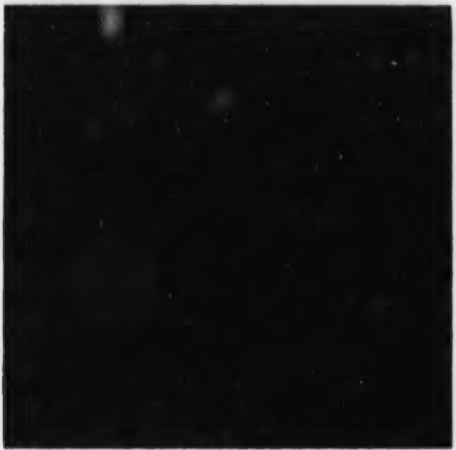


Fig 18. Mortality of western hemlock caused by conifer sawfly.

TREE SPECIES ATTACKED:

Western hemlock and amabilis fir are most frequently attacked, but Sitka spruce may also be damaged. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are present from June to August. Newly emerged larvae are almost black, with a shiny black head. Mature larvae are 1.5 to 2.0 cm long and are green or yellow-green, with a broad medium-dark band on each side and a narrower, darker band below that. The head remains dark.

Larvae are wasteful feeders of older foliage; current foliage may be eaten under starvation conditions. Larvae often feed in colonies, especially when young. When disturbed, larvae will hold on with hind legs and flick the front of the body. Cocoons are formed during July and early August and are commonly found in the lower crown under twigs or needles or on understory vegetation. They are 0.5 to

Fig 19. Larvae of conifer sawfly.

1.0 cm long, cylindrical, have rounded ends, vary from light grey to brown in colour, and are tough and papery.

Damage:

Conifer sawfly usually affects older foliage only. Therefore, mortality is not common but some top-kill and radial growth loss may occur. The potential for mortality is greatly increased by repeated defoliation, or when conifer sawfly occurs with defoliators that prefer current foliage, such as western blackheaded budworm. Conifer sawfly damage may predispose trees to secondary attacks by other insects or fungi. Outbreaks are usually short-lived.

Similar Damage:

Western hemlock looper defoliation may be confused with conifer sawfly damage, but the larvae are easily distinguished from each other.

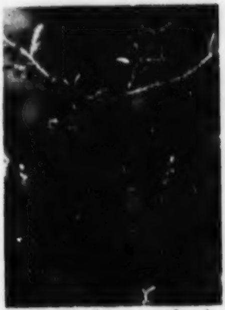


Fig 20. Older foliage is preferred.

LARCH SAWFLY

Pristiphora erichsonii (Htg.)

DISTRIBUTION

On western larch in the east Kootenays and throughout the range of eastern larch (tamarack) in northern BC.

Fig 21. Maturing larch sawfly larvae. Gregarious feeding is common.

TREE SPECIES ATTACKED:

All ages of western larch and eastern larch are attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Young larvae have cream-coloured bodies and brown heads. As they mature, their bodies become greenish and eventually grey-green on top and whitish underneath. The heads darken to become shiny black. Full-grown larvae reach 2.0 cm in length, and may be seen holding on with their forelegs and arching their back with their posterior end over the head.

Eggs are laid in slits in terminal shoots and twigs in June or July. Larvae emerge from the slits shortly thereafter and feed in groups, stripping the foliage as they move down the branch. Terminal shoots and twigs are damaged during egg-laying and may be left curled and distorted for several years. The larvae drop to the litter layer and spin paper-like, capsule-shaped, brown cocoons to spend the winter. They pupate in early spring.

Fig 22. Tip curl is an early symptom of larch sawfly attack.

LARCH SAWFLY

Fig 23. Severely defoliated larch due to larch sawfly infestation.

DAMAGE:

Larch are very tolerant of defoliation; therefore, no reports of direct tree mortality on western or eastern larch have resulted from larch sawfly attack in British Columbia. Growth reduction and branch mortality may, however, occur following outbreaks. Outbreaks may cover thousands of hectares.

SIMILAR DAMAGE:

Light defoliation may be confused with bud moth, larch needle cast, larch needle blight, or larch casebearer damage. Close examination will reveal distinct differences.

PINE NEEDLE SHEATHMINER

Zelleria haimbachi (Bsk.)

Distribution

Throughout southern BC.

Fig 24. Pine needle sheathminer larvae are relatively small and tan-coloured.

Tree Species Attacked:

Lodgepole pine, ponderosa pine, and occasionally white pine are attacked. It is found mostly in juvenile stands.

Insect Description & Damage Symptoms:

Immature larvae are about 0.2 cm long and reach 1.4 cm prior to pupation. Larvae are tan-coloured with two dull-orange stripes running lengthwise along the back. The colour changes to a greenish hue before pupation. Brown pupae can be found in the mass of silken webbing around the needle bases in early summer.

On damaged trees, the current year's foliage appears faded and needles may be shorter than normal. Some needles may droop back, or hook, towards the needle base. A small hole may be noted in the sheath surrounding an attacked fascicle. By late summer, damaged needles are shed and commonly accumulate in webs along the main stem. Feeding occurs throughout the growing season.

Fig 25. Fading of current year's foliage due to attack by pine needle sheathminer.

DAMAGE:

Attacks usually occur in juvenile to immature pine stands. Damage is restricted to the current year's foliage, but up to 100% of the new growth may be destroyed over hundreds of hectares. The extent of defoliation varies among trees within an attacked stand, and some trees may escape attack entirely. Tree mortality has not been associated with this insect. However, growth reduction resulting from defoliation has been documented in ponderosa pine plantations.

SIMILAR DAMAGE:

Damage may be confused with pine needle cast disease. Sheaths mined by the sheathminer are distinctive in that they result in needles being easily pulled out, leaving the sheath attached to the twig. Needle cast disease results in shedding of needles complete with the sheath. Needles affected by *Lophodermella* shed the previous year's needles in the summer, while the pine needle sheathminer affects the new year's growth.

Fig 26. Frass, webbing, and necrotic needles resulting from attack by pine needle sheathminer.

LARCH CASEBEARER

Coleophora laricella (Hbn.)

DISTRIBUTION

Southeastern BC from the Okanagan Valley east to the Crowsnest Pass and north to Vernon. Defoliation is more common at lower elevations.

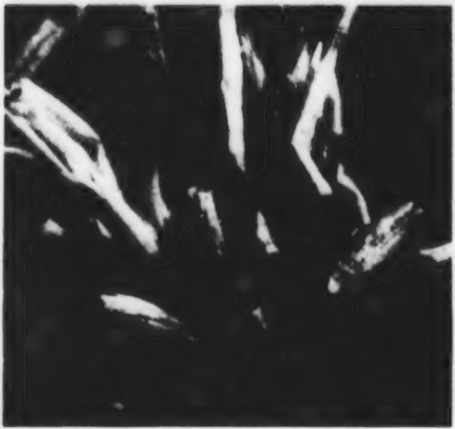


Fig 27. Mined needles and cigar-shaped case of mature larch casebearer larvae.

TREE SPECIES ATTACKED:

All ages of western larch are attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Mature larvae are 0.5 cm long and are dark reddish-brown with a black head. Young larvae mine a single needle and fabricate a hollow shelter, called a "case," from a section of the needle. This case is straw-coloured and rectangular, becoming grey and cigar-shaped prior to pupation. Larvae move about and feed on needles while enclosed in the case. By fall, the larvae fasten the case to twigs or a needle fascicle to overwinter. Foliage damage is most visible in May when late-instar larvae are feeding on new foliage. The larvae pupates in late May or early June, still staying within the case.

Fig 28. Straw-coloured foliage of larch attacked by larch casebearer.

The new foliage of lightly attacked larch turns light green to straw-coloured and will curl at the end. A severe attack will produce reddish needles, which create a scorched appearance. Defoliation is usually lightest in the lower crown and increases with height. Late-instar larvae feeding in the spring are responsible for the majority of damage. In severe attacks, foliage may be consumed as fast as it is produced. Trees often flush again in June if defoliated in May.

Fig 29. Defoliation of new foliage by larch casebearer.

DAMAGE:

Larch are relatively resistant to the effects of defoliation. However, after five years of severe defoliation, annual terminal and radial growth may be seriously affected.

SIMILAR DAMAGE:

Larch casebearer damage is often confused with larch needle cast or larch needle blight. Larch sawfly and bud moth damage is similar from a distance, but chewed needles distinguish this damage. Look for the distinctive cases to identify the larch casebearer.

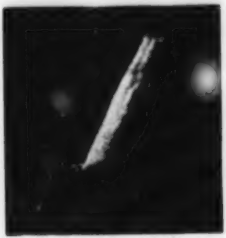


Fig 30. Rectangular case of immature larch casebearer larva.

WESTERN FALSE HEMLOCK LOOPER

Nepytia freemani (Mun.)

DISTRIBUTION

Primarily occurs in the IDF biogeoclimatic zone, most often occurring in Douglas-fir stands growing on dry, rocky sites.

Fig 31. Late instar larva of western false hemlock looper. Note square head and alternating dark and light stripes.

TREE SPECIES ATTACKED:

Primarily immature Douglas-fir trees are attacked, and occasionally hemlock, Engelmann spruce, subalpine fir, ponderosa pine, and larch.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The "inch worm" larvae start feeding with the flush of new growth in the spring. Mature larvae have a broad, reddish-brown dorsal stripe bordered by narrow yellow stripes. Each side is marked with a wide yellow stripe. The larvae are approximately 3 cm long. The head appears almost square from above and has black dots. The pupae are light amber, becoming dark red-brown, 1.2 to 2 cm long, and are loosely contained in a cocoon of woven hairs.

Feeding begins in May in the upper crown on the underside of newly flushed foliage. In late June through August, the larvae move down the crown and consume older foliage. Most needles are only partially eaten. Larvae are solitary feeders but may gather in webbed enclosures to pupate. Defoliation becomes noticeable in June. Abundant webbing is evident in heavily infested stands.

Fig 32. Feeding by western false hemlock looper begins in new foliage of tree tops.

DAMAGE:

During serious outbreaks, trees may be completely defoliated in one season. Douglas-fir usually recovers from a single defoliation. Repeated attacks, however, can result in top-kill or mortality.

SIMILAR DAMAGE:

Damage is similar to other defoliators, such as the western spruce budworm, but the larvae are very distinctive.

Fig 33. Western false hemlock looper larvae gradually consume older foliage further down the crown.

WESTERN HEMLOCK LOOPER

Lambdina fiscellaria lugubrosa (Hulst)

DISTRIBUTION

Primarily occurs south of 56 degrees latitude and is most common along the coast and in the interior wet belt of BC. Outbreaks have occurred on stands from sea level to 1400 m elevation.

Fig 34. Mature larva of western hemlock looper on larch. Note intricate pattern of markings.

TREE SPECIES ATTACKED:

Western hemlock is the preferred host, but during outbreaks the looper feeds on almost any foliage, including broad-leaved forest trees and shrubs. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are typical "inch worm" loopers and are approximately 3.5 cm in length when mature. Young larvae are marked with light grey and black bands. Mature larvae are mottled grey to dark brown with an intricate pattern of darker markings. Each abdominal segment is marked with four prominent dark spots, which roughly form a square.

Larvae emerge in late spring and begin feeding in newly opened buds in the upper crown. Later, the larvae feed on foliage of any age and disperse throughout the crown. The larvae are wasteful feeders. Many needles are only partially chewed; some are severed at the base and accumulate below an attacked tree. Mature larvae are quite mobile and produce an abundance of silk webbing, which is very evident in defoliated stands. The larvae pupate in late summer in bark crevices, moss, lichen, or in debris on the forest floor. The pupae are a mottled greenish-brown, 1.1 to 1.5 cm long. The crowns of heavily attacked trees turn yellowish-red at first and eventually reddish-brown. Defoliation occurs most commonly on sites located in valley bottoms with a major western hemlock component, and is often in distinctive elevational bands.

DAMAGE:

Western hemlock in the interior is intolerant of defoliation; thus, mortality can occur following only one year of heavy defoliation and may continue for up to four years after the collapse of a western hemlock looper infestation. Coastal hemlock seems much more resilient.

Most hemlock can recover from less than 50% defoliation.

Fig 35. Western hemlock looper usually begins feeding on current growth in late spring

The wasteful feeding habit of this insect greatly increases the amount of damage relative to most other defoliators. Older hemlock, amabilis fir, and Sitka spruce are most vulnerable to damage, while young Douglas-fir appears to suffer more than older. Outbreaks generally last for three years. Serious damage has occurred in hemlock/true fir mixes on the coast and hemlock/cedar stands in the interior wet belt of the province.

SIMILAR DAMAGE:

Damage may be similar to other defoliators, such as the western blackheaded budworm, but the larvae are distinctive.

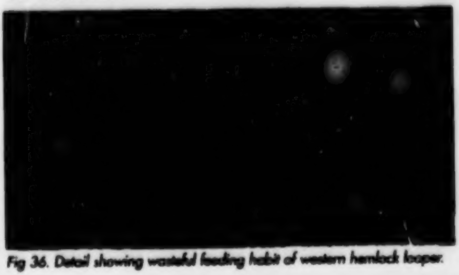


Fig 36. Detail showing wasteful feeding habit of western hemlock looper.

GREEN-STRIPED FOREST LOOPER

Melanolophia imitata (Walker)

Distribution

The green-striped forest looper is most common along the coast and interior wet belt of BC.

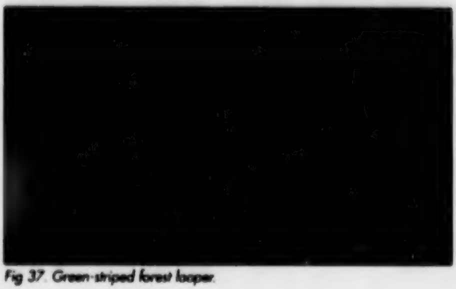


Fig 37. Green-striped forest looper.

Tree Species Attacked:

Mainly conifers are attacked, although many broad-leaved trees and shrubs may also be defoliated. The preferred host trees are western hemlock, western redcedar, and Douglas-fir. All ages are susceptible.

Insect Description & Damage Symptoms:

The adult moths are a mottled grey-brown and have a wingspan of 20 to 40 mm. They fly from mid-March to mid-June and deposit their eggs singly on tree branches and trunks. The larvae feed on all foliage, but they prefer one-year old foliage. Young larvae are dull olive-green with dark lines, changing to deep apple-green with whitish and yellowish stripes as they mature. A mature larvae is between 22 and 37 mm in length. Young larvae feed on the underside of leaves. As they mature, they chew off sections of needles. Defoliation becomes noticeable by mid-July, and in August, damaged trees appear brown with a thinning crown. Feeding is usually heaviest in the upper crown and on the understory. In late summer, the larvae drop to the ground and pupate in the litter layer. The pupae are brown, and 10 to 17 mm in length.

DAMAGE:

The green-striped forest looper was not considered to be destructive until the early 1960's, when significant top-kill and mortality of western hemlock and western redcedar occurred on Vancouver Island and the Queen Charlotte Islands. Heavy defoliation can occur in scattered isolated areas. Tree mortality, particularly of the understory, can be the result of severe infestations.

SIMILAR DAMAGE:

Young larvae feeding on the underside of leaves can cause damage that resembles leaf miners or skeletonizers. As the larvae mature, however, it becomes evident that the damage is caused by a serious defoliator. Damage by other defoliators, such as the conifer sawfly, may be confused with the green-striped forest looper, but the larvae are easily distinguished from each other.

BLACK ARMY CUTWORM

Actebia fennica (Tausch.)

DISTRIBUTION

Damaging populations have occurred in the central and southeastern interior.

Fig 39. Conifer seedling defoliated by black army cutworm.

Fig 40. Black army cutworm feeding on herbaceous vegetation.

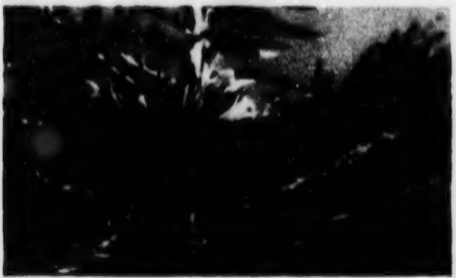


Fig 38. Black army cutworm larva. Note fine double lines along the abdomen.

TREE SPECIES ATTACKED:

All conifer seedlings are attacked, most commonly white spruce and lodgepole pine.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are velvety black on the upper surface, with two pairs of fine, white, double lines running the full length of each side of the body. The underside is grey. The larvae range from about 0.5 cm long during the overwintering stage, to about 4.0 cm when mature in June. Larvae feed during the day in early spring, but switch to night feeding in late spring. Mature larvae pupate in the litter layer in late June.

Although larvae prefer to feed on herbaceous plants and shrubs, such as fireweed, they will defoliate coniferous seedlings in the absence of preferred hosts. First evidence of cutworm feeding is "shot holes" in leaves of herbaceous vegetation. Attacked coniferous seedlings may be partially or completely defoliated, buds may be damaged, and succulent young stems may be clipped off.

At the beginning of an outbreak, larval feeding is usually clumped in distinct patches measuring a few hundred metres across, usually located on the upper portion of south-facing slopes. Little or no sign of feeding can be seen between patches. Patches enlarge and coalesce as the larvae migrate and consume new plants. Larvae are not normally observed during the day, but can be found buried within the litter or hidden within stalks or unopened leaves of certain plants, such as Indian hellbore. If palatable food becomes scarce or the soil becomes too wet, larvae can be observed on the surface searching for food.

Fig 41. Current growth of spruce seedling after severe defoliation by black army cutworm the previous year.

DAMAGE:

Adult moths are attracted to recently burned areas to lay their eggs. Sites burned in early summer the previous year, or in late summer to fall two years previously, are the most attractive. If preferred vegetation is scarce when larvae emerge in the spring, the potential for damage to planted coniferous stock is very high, especially if the cutworm population is high. Severe defoliation may result in seedling mortality or deformity. Although attacks can be devastating locally, this insect seldom causes significant damage for more than one season.

SIMILAR DAMAGE:

Death or deformity of seedlings from factors such as frost, incorrect planting, voles, or rhizina root disease, may be confused with black army cutworm, once the needles have fallen off. Evidence of partially chewed needles and the larvae themselves will distinguish the black army cutworm.

TRISETACUS MITE

Trisetacus ehmanni (Keifer)

DISTRIBUTION

Most likely throughout the host range in BC.

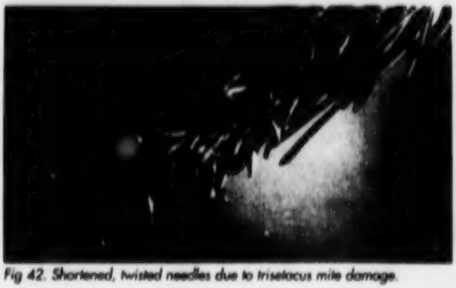


Fig 42. Shortened, twisted needles due to trisetacus mite damage.

TREE SPECIES ATTACKED:

Young lodgepole and ponderosa pine are susceptible.

DESCRIPTION & DAMAGE SYMPTOMS:

This tiny mite feeds within the needle sheath on the current year's needles. The result is a twisting and shortening of the needles, which then turn yellow and drop prematurely. On repeatedly attacked trees, the twigs may become twisted. The pattern of attack is usually scattered, single trees throughout a stand.

DAMAGE:

Damage is restricted to distortion and loss of the current year's needles. This can result in growth loss.

SIMILAR DAMAGE:

Nutrient deficiencies or abiotic damage such as frost can sometimes appear similar, but abiotic damage is usually more extensive than with the trisetacus mite.

SUCKING INSECTS

Sucking insects, primarily aphids, affect either foliage or the branches and the main stem. Foliage attacks are characterized by chlorotic mottling or needle drop due to the removal of sap during the feeding. Stem or branch attacks can result in galls on the branch tips, swellings and deformities on the branches and main stem, or growth reduction. These galls, swellings, and deformities result from the injection of digestive juices into the host when the sucking insects feed.

Winged or wingless adults, and nymphs (immature insects that resemble the adults), are often present in large congregations on the foliage, stems, and branches. Depending on the species, adults and nymphs may be covered with a white and waxy deposit, which gives them a cottony appearance. Other species are smooth, oval, and greenish to black. Sucking insects may be mobile or permanently positioned on a particular feeding spot. Life cycles of most species are complex and some require alternate hosts for completion.

Douglas-fir, true fir, and spruce species are the most frequent hosts, but attacks are generally sporadic. Balsam woolly adelgid causes the most significant damage. Damage varies according to host; however, growth reduction and occasional mortality can result. Epidemics are usually of short duration. The sporadic nature of outbreaks and the very high reproduction rate of these insects make control efforts difficult.

BALSAM WOOLLY ADELGID

Adelges piceae (Ratz.)

DISTRIBUTION

Evidence indicates that all stands containing true firs within the southwest portion of BC, including Vancouver Island, may eventually be at risk.

Fig 43. Balsam woolly adelgid adults without tufts.

TREE SPECIES ATTACKED:

All true firs are susceptible, with amabilis and grand firs attacked most frequently. Grand fir is the most tolerant of attacks; sub-alpine fir is the most easily damaged. All ages are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are tiny (less than 0.1 cm) and covered with wool-like wax threads. Masses of feeding adults, appearing as thousands (up to 100 per sq.cm) of tiny (0.1 cm av. diameter) tufts of wool, may be visible on the smooth bark of younger trees and in the bark crevices of older trees.

Rubbing the wool tufts during summer months should produce a purple stain on the fingers.

Fig 44. Distorted crown resulting from balsam woolly adelgid attack.

Crown-attacked trees have thin, chlorotic to red-brown upper crowns, stunted terminal growth, and possibly dead tops. Closer examination of the top will reveal swellings around buds and branch nodes, called "gouting". Decay fungi may be associated with these symptoms.

Stem-attacked trees exhibit a general decline, with the entire crown being chlorotic to red-brown and possibly thin. Stem attack, however, is less common than, but always associated with, crown attack. This insect is difficult to see during the winter months. Therefore, diagnosis during winter should be based on gouting and crown symptoms.

DAMAGE:

Attacks occur most commonly on large trees, but all age classes of trees are susceptible. The intensity of attack will vary within an infested stand. Outbreaks have been associated with sites disturbed by logging, road building, or drought. Crown attack produces dead tops and growth reduction, but most trees can survive crown attack for several years. Stem attack has a more severe effect on the host tree, which may die following 2 to 3 years of repeated infestations. Wood quality is also adversely affected.

Fig 45. Stunted terminal growth from continual balsam woolly adelgid crown infestation.

SIMILAR DAMAGE:

May be mistaken for damage caused by scale insects. Wool-covered females and gouts are distinctive.

Fig 46. Gouting due to infestation by balsam woolly adelgid.

Fig 47. Wool-like tufts cover feeding balsam woolly adelgids.

COOLEY SPRUCE GALL ADELGID

Adelges cooleyi (Gill.)

DISTRIBUTION

Throughout BC wherever Douglas-fir is established.

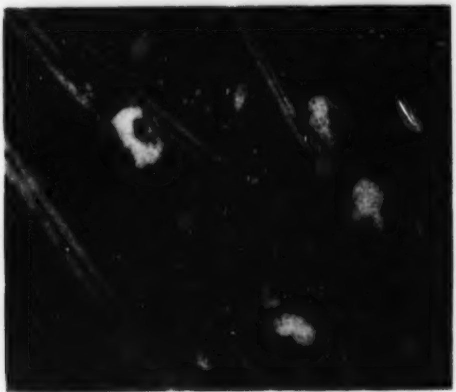


Fig 48. Non-tufted and tufted cooley spruce gall adelgids on Douglas-fir foliage. Note wool-like appearance of tufts.

TREE SPECIES ATTACKED:

Attacks alternate between Douglas-fir and Sitka, Engelmann, or white spruce. All ages of trees are susceptible, but the damage is most severe on immature spruce.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

On Douglas-fir, adults are about 0.1 cm long, oval, and light to dark brown in colour. At maturity they are completely covered with white, waxy wool and appear, from spring to fall, as stationary wool tufts on the underside of needles. The needles of light to moderately infested trees exhibit chlorotic mottling where individual adults have fed. Attacked needles may also be twisted. Severely infested foliage may be completely chlorotic and drop prematurely.

Fig 49. On Douglas-fir, infestation by cooley spruce gall adelgid is characterized by white tufts from spring to fall.

On spruce, the adult is similar to that found on Douglas-fir. Infested spruce display cone-like galls at the ends of branches. These galls are 1 to 8 cm long with separate chambers. New galls are green, pink, or purple, and flexible; the chambers are closed and may contain aphids. As they age, galls become brown, hard, and brittle. The chambers are open and empty. Old galls may persist on spruce branches for several years.

Fig 50. New gall (above) on spruce caused by cooley spruce gall adelgid. Old gall (below) is necrotic and brown.

DAMAGE:

On Douglas-fir, light infestations are very common, though not seriously damaging. Significant damage, however, including needle loss and growth reduction, occurs sporadically when young trees are severely attacked. Heavy infestations and damage may be indicative of environmental stress.

On spruce, repeated attacks can produce stunted, deformed trees, but normally, cooley spruce gall adelgid is not a serious concern in spruce stands.

SIMILAR DAMAGE:

Some species of the woolly aphid genus *Pineus* form galls on spruce that can be confused with *Adelges* galls. The *Pineus* gall chambers are inter–connecting, while cooley spruce gall adelgid chambers are non–connecting.

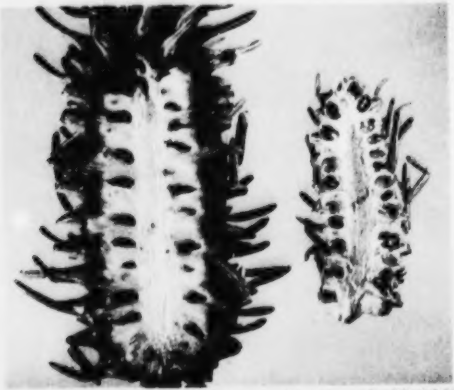


Fig 51. Cross-sectional difference between cooley spruce gall adelgid (left) and Pineus.

GIANT CONIFER APHID

Cinara spp.

DISTRIBUTION

Throughout BC.

Fig 52. Giant conifer aphid nymphs and adults.

Fig 53. Chlorosis due to feeding by giant conifer aphid.

TREE SPECIES ATTACKED:

All native conifers are attacked, but especially lodgepole pine. It attacks predominately immature trees.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adult giant conifer aphids are pear-shaped, 0.2 to 0.5 cm in length and usually dark-coloured. Adults have long, slender legs and may have wings. Nymphs are similar in shape and colour to adults, but lack wings and are slightly smaller. The aphids feed in a stationary group and may be found on branches, roots, or the main stem. A clear, sticky liquid, called honeydew, is exuded from the posterior of each aphid. Ants frequently harvest honeydew from the aphids. A black, sooty mold often develops on foliage and branches covered by honeydew. Foliage of infested trees may become chlorotic.

DAMAGE:

Attack can cause growth reduction in young conifers. Studies have shown that the leaders of infested trees may be only one-quarter to one-half the length of similar non-infested trees. Aphid attack may predispose a tree to secondary insects, pathogenic fungi, or excessive drought stress.

SIMILAR DAMAGE:

May be mistaken for needle cast or blight during a severe infestation. However, aphid damage is not as widespread as needle diseases. Look for aphids at the bases of affected needles.

Fig 54. Giant conifer aphid is a gregarious feeder. This large congregation is on spruce.

GREEN SPRUCE APHID

Elatobium abietinum (Wlk.)

DISTRIBUTION

Throughout coastal BC wherever Sitka spruce occurs. Believed to be introduced from Europe.

Fig 55. Green spruce aphids feeding on the underside of needles.

TREE SPECIES ATTACKED:

Sitka spruce, Norway spruce, and blue spruce are preferred; other spruce species may also be attacked. All ages of trees are susceptible, though damage is most severe on immature spruce.

Fig 56. Crown discolouration resulting from green spruce aphid infestation.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Nymphs or adult aphids are found on the lower surface of needles where they suck the sap. Old needles are preferred over current growth. Nymphs are wingless, oval, and green, and approximately 0.1 cm long. Adults may be winged or wingless, and are 0.2 cm long, but are otherwise similar in body shape and colour to nymphs. Adults have a yellow-green head and dull red eyes. Eggs are oval-shaped and are yellowish-red to brown or black. Foliage discolouration and defoliation are most noticeable in spring. Individual needles exhibit chlorotic mottling. Infested crowns turn a dull green to brownish colour.

DAMAGE:

The nymphs' feeding habits cause foliage discolouration and subsequent needle drop. Severe and extensive damage is occasionally reported on the Queen Charlotte Islands, particularly on trees growing along the shoreline. In other areas, infestations tend to be sporadic in nature and rarely affect more than several hundred trees. Trees are usually only partially defoliated and recover with some loss in growth rate. Complete defoliation and mortality occur occasionally.

SIMILAR DAMAGE:

None, except frost from previous years if it kills older needles.

Fig 57. Chlorotic mottling due to attack by green spruce aphid.

Fig 58. Severe needle drop after attack by green spruce aphid.

WOODY TISSUE FEEDERS

Most woody tissue feeders are bark beetles, but there are also several weevils, midges, and moths that feed on woody tissue.

BARK BEETLES:

Bark beetles pose a serious threat to the health of mature coniferous forests in British Columbia. Each year, they attack thousands of hectares of trees. Bark beetles destroy more timber than any other insect damage agent.

Adult bark beetles bore under the bark of trees and lay their eggs along galleries in the phloem. When the larvae hatch from these eggs, they feed on the phloem and cambium tissues. Adults also introduce a complex of fungi, usually referred to as blue stain fungi, which colonize and kill sapwood cells. The tree dies as a result of being girdled by a combination of fungus-killed cells and feeding larvae. Outbreaks initially occur in old seral stands of coniferous trees, or in mature stands that are stressed by drought, defoliation, root diseases, or other damaging agents. Some bark beetle species, however, are capable of attacking healthy trees whenever population numbers are sufficient to overcome a tree's resistance and if appropriate environmental conditions prevail. Severe outbreaks of some species of bark beetle also occur as a result of beetle populations building up in logging slash or windfalls.

The life cycles of the various bark beetle species follow a similar pattern. The beetles overwinter under the bark of infested trees as young or mature adults, or larvae in various stages of development (only rarely do they overwinter as eggs). The young adults complete their maturation and leave their original host to find another. The mature larvae pupate while younger larvae complete their development and then pupate. Any overwintering eggs hatch and begin the first stages of larval development. The length of the life cycle depends upon the species, geographical location, and the prevailing weather conditions.

The adults of each species of bark beetle can be distinguished from each other by colouring, size, and body features. Additionally, they tend to be very host-specific and have unique gallery patterns. The eggs, larvae, and pupae, however, exhibit few differences between species. Eggs are usually pearly white, ovoid, and 0.5 mm to 1 mm long. Larvae are white, legless, stout-bodied grubs with pale, brown heads. They range from 1 to 7 mm in size depending on their instar level. Pupae are pale white to light tan and tend to show signs of adult features.

Damage symptoms vary by species, but attacked trees generally exhibit discoloured foliage, boring dust, woodpecker damage, and pitch tubes. Larval galleries are also apparent under the bark.

Weevils, Midges, and Moths:

Juvenile trees, from seedlings to pole-sized individuals, are more prone to attack by other types of woody tissue feeders, including weevil species, midges, and pitch moths. These insects feed primarily on the innermost bark (phloem) of the roots, root collar, leaders, branch tips, or branch junctions.

The larval stage is usually responsible for most of the damage, with the exception of the conifer seedling weevil. Larvae create girdling patterns, pitch nodules, or dead or broken leaders and tips. Larvae of Warren's root collar weevil and the northern pitch twig moth usually feed individually, while larvae of other species may feed in groups. Adult weevils have distinctive snouts, and adult gouty pitch midges resemble mosquitoes.

Leader and branch crotch attacks may cause reduced growth, breakage, deformity, and dieback. Weevil-killed terminals can be distinguished from those killed by other agents by the presence of round adult exit holes or larvae feeding inside the terminals.

MOUNTAIN PINE BEETLE

Dendroctonus ponderosae (Hopkins)

DISTRIBUTION

Throughout the range of its principal host, the lodgepole pine.

Fig 59. Adult in a gallery.

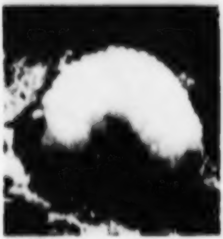


Fig 60. Larva.

Fig 61. Pitch tubes usually appear from the duff line to a top diameter of 15 cm.

TREE SPECIES ATTACKED:

Large-diameter, mature, and old growth lodgepole pine are by far the most commonly affected tree species. Western white, whitebark, and ponderosa pine may also be attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Generally, mountain pine beetles have a one-year life cycle. Two-year cycles are common at high elevation and in northern latitudes. The adults are hard, stout-bodied, cylindrical insects, ranging in length from 3.5 to 6.5 mm. They have black heads and thoraxes, and black or brownish bodies. Adults construct vertical egg galleries in the phloem and cambium tissues. The galleries are straight or slightly sinuous, with a short crook or bend at the bottom. The galleries nearly always follow the grain of the wood and are packed with frass. Overwintering larvae resume feeding in April and complete development in June. Pupae transform into adults during mid-summer and emerge in mid-July through early September to attack a new host.

Damage symptoms include reddish boring dust at the base of attacked trees and bark removal by feeding woodpeckers. Trees respond to infestation attack by releasing quantities of resin, which mixes with the boring dust and forms a soft, white or reddish pitch tube around each bore hole. These pitch tubes usually appear from the duff line to a top diameter of 15 cm. Tree foliage turns yellow and then red by the spring of the year following the initial beetle attack. Most of the needles drop from the tree after two years, leaving a gray snag.

Fig 62. Attacked trees. Note: red colour is usually visible within a year following attack.

DAMAGE:

Mountain pine beetles primarily attack living, older, large-diameter trees. Outbreaks initially occur in less healthy, old seral stands, but as more trees become infested, the beetle population increases and spreads to healthy and progressively smaller trees. As a result, huge areas of pine may be killed. In addition to direct volume loss, outbreaks disrupt harvesting plans, reduce aesthetic value in recreation areas, and increase fire hazard.

Trees are killed when the flow of food and water between the roots and needles is blocked by a combination of feeding larvae and dead sapwood cells killed by the blue-stain fungus carried by the mountain pine beetle adults. Blue stain and checking of sapwood lowers the commercial value of salvaged trees killed by mountain pine beetles.

SIMILAR DAMAGE:

Attacks by secondary bark beetles may produce boring dust in bark crevices. Ips beetle species can be distinguished by the gallery patterns and the lack of frass in galleries. The adult ips beetle differs from the mountain pine beetle in that it has a rear concave depression lined with spines.

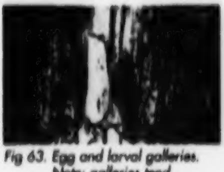


Fig 63. Egg and larval galleries. Note: galleries tend to follow the grain of the wood.

Care must be taken not to confuse pitch blisters with the pitch tubes of the mountain pine beetle. If uncertain, removing the bark to check for galleries will confirm identification.

SPRUCE BEETLE

Dendroctonus rufipennis (Kirby)

DISTRIBUTION

Throughout the range of spruce.

TREE SPECIES ATTACKED:

Large-diameter, mature spruce species are attacked, including Engelmann, white, Sitka and, rarely, black spruce.

Fig 64. Woodpecker bark scaling of an attacked tree.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The spruce beetle usually has a two-year life cycle although a one-year cycle can occur in some areas. Where this occurs, it can result in the doubling of beetle flight numbers. The larvae feed in the phloem, usually gregariously, often forming fan-shaped galleries. Two anal shields are present on the larvae, which occur on only one other *Dendroctonus* species, the lodgepole pine beetle. Adults are hard, stout-bodied, cylindrical insects, ranging in length from 4 to 7 mm. They are black-brown or black with reddish wing covers. Spruce beetles must overwinter once to fully mature. Mature adults emerge and attack fresh host material from late May to early July. Some immature adults may emerge in the fall to overwinter at the base of the tree.

Adults construct long galleries in the phloem. Light brown to red-brown boring dust will be present on

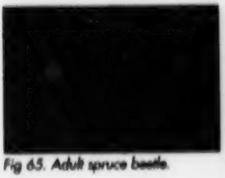


Fig 65. Adult spruce beetle.

Fig 66. Trees fade to yellowish-green and then grey within a year following an attack.

the bark or around the base of infested trees. Pitch tubes are rarely formed by resin flowing out of the entrance holes made by attacking beetles. Sometimes flaking of the bark by woodpeckers is a sign of infestation. Fading of the foliage to a yellowish–green is usually not noticeable until 18 months or longer following attack, particularly on rich sites. By the second autumn, most of the needles have usually turned brown and are shed by the following spring. Green needles on the ground or on the leaves of ground cover beneath infested trees may appear before any evidence is visible in the crown itself.

Fig 67. Egg and larval galleries are up to 13 cm long. Frass is usually present in the galleries.

DAMAGE:

Spruce beetles normally infest downed trees or logging debris, but when beetle populations are large, they will attack and kill living trees, causing widespread damage. Trees are killed when the flow of food and water between the roots and needles is blocked by a combination of feeding larvae and dead sapwood cells killed by the blue-stain fungi carried by the spruce beetle adults.

SIMILAR DAMAGE:

Attacks by secondary bark beetles may produce boring dust in bark crevices. Ips beetle species can be distinguished by the gallery patterns and the lack of frass in galleries. The adult ips beetle differs from the spruce beetle in that it has a rear concave depression lined with spines. Spruce beetle larvae can be distinguished from most other *Dendroctonus* species by the presence of two anal shields.

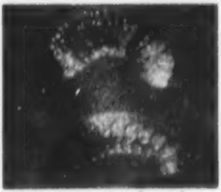


Fig 68. Larvae. Note the anal shields.

DOUGLAS-FIR BEETLE

Dendroctonus pseudotsugae (Hopkins)

DISTRIBUTION

Throughout most of the range of its principal host. Damage is usually most intensive in the interior of BC.

Fig 69. Larva in gallery.

Fig 70. Adult Douglas-fir beetle.

TREE SPECIES ATTACKED:

Large-diameter, mature Douglas-fir trees are attacked, and occasionally, downed western larch.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are dark brown to black with reddish wing covers and about 4.4 to 7 mm long. The usual life cycle is one year, but two broods may be produced. The main flight period usually occurs in May and June, while a second flight in July and August may be made by adults developed from overwintering larvae or adults re-emerging after the earlier flight.

Fig 71. Egg and larval galleries are about 30 cm in length and packed with frass.

Adults lay their eggs in long galleries constructed parallel to the grain of inner bark. Reddish boring dust may be found in bark crevices or at the base of the tree. Adult beetles will often not attack the bottom portion of the bole, making identification difficult. Pitch tubes are not formed, but the tree may exude resin from upper attacks. Foliage of killed trees turns from green to pale yellow-green to red by the spring of the year following the attack. Red needles may remain on the tree for up to two years after an attack and aerial spotting of these "redtops" helps to determine the extent of an outbreak. Sometimes needles will drop without any discolouration.

Fig 72. Attacked trees. Note: red colour usually appears by the spring of the year following an attack.

DAMAGE:

Douglas-fir beetles normally infest felled trees, mature damaged trees, logging debris, and trees stressed by drought. When sufficient host material is unavailable, however, they will attack and kill vigorous trees, causing more extensive damage. Trees are killed when the flow of food and water between the roots and needles is blocked by feeding larvae and by dead sapwood cells killed by the blue-stain fungi carried by the Douglas-fir beetle adults. On the coast, it often takes two years of attack to kill a tree (partial or "strip" attack occurs the first year).

SIMILAR DAMAGE:

Attacks by secondary bark beetles may produce boring dust in bark crevices. The Douglas-fir pole beetle is usually found in the smaller diameter, upper portion of the stem. It can be distinguished from the Douglas-fir beetle by its finer boring dust and different gallery patterns.

Fig 73. Boring dust can be found in crevices at the base of the tree.

WESTERN BALSAM BARK BEETLE

Dryocoetes confusus (Swaine)

DISTRIBUTION

Follows the range of its primary host, sub-alpine fir. In BC, sub-alpine forests cover large areas of the interior.

Fig 74. Adult.

Fig 75. Larva.

TREE SPECIES ATTACKED:

Primarily sub-alpine fir is attacked, but occasionally, amabilis fir. Some attacks of white spruce and Engelmann spruce have been recorded. Mature trees are targeted.

Fig 76. Attacked trees. Note: this colour usually appears within a year following an attack.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are 3.4 to 4.3 mm long, dark brown, and covered with erect, red-brown hairs. They emerge in late May or June. The life cycle normally requires two years, but given the right climatic conditions, it could be completed in one year.

The extent of an infestation is difficult to determine as a result of overlapping life cycles, a lack of telltale pitch tubes, and the fact that the majority of the attacks occur above 2 m on the bole. The adults construct egg galleries that have a central nuptial chamber with brood galleries radiating from the top and bottom. A mixture of boring dust and frass is usually found in bark fissures and at the base of the bole. The foliage of an attacked tree will change from green to a bright, brick-red colour in the year following the attack, but the red needles may be retained for up to five years.

DAMAGE:

Given the appropriate conditions, balsam bark beetles can be responsible for extensive tree mortality in stands containing a large percentage of the preferred host. Normally, however, less than 5%

of a stand is attacked in a single season, with the damage usually scattered throughout the stand. The adult carries a lesion-causing fungus, *Ceratocystis dryocoetidis*, which is responsible for an estimated 65% of the mortality associated with balsam bark beetles. The lesions caused by the fungus may girdle and kill a tree, and they also make the tree susceptible to further beetle attacks.

Fig 77. Egg and larval galleries.

WESTERN PINE BEETLE

Dendroctonus brevicomis (LeConte)

DISTRIBUTION

Throughout the range of ponderosa pine west of the Rocky Mountains.

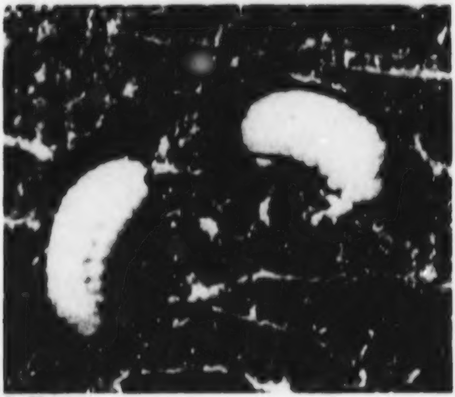


Fig 78. Larvae.

TREE SPECIES ATTACKED:

Mature to old ponderosa pine trees are attacked.

Fig 79. Egg and larval galleries are usually packed with dust.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

One to two generations of beetles are produced every year, depending upon the elevation. Adults are brown to black, cylindrical, stout-bodied, hard-shelled, and about 3 to 5 mm long. They construct long, meandering, dust-packed galleries in the cambium of attacked trees. During periods of heavy attack, the galleries may cross and re-cross, forming a complex network. The timing of western pine beetle attacks depends upon elevation, but in British Columbia they can occur any time from May to September.

Reddish-brown boring dust will be present on the base of attacked trees. Inconspicuous reddish-brown pitch tubes can sometimes be found in bark crevices. Needles will pale and then fade to yellow, to reddish–brown, and finally to red in the months following the attack. Flaking of the bark by woodpeckers in search of beetles or larvae is also a symptom of infestation.

WESTERN PINE BEETLE

Fig 80. Killed ponderosa pine.

DAMAGE:

Usually, the western pine beetle breeds in scattered, old, slow-growing, or diseased trees; and trees weakened by stand stagnation, lightning, fire, or mechanical injury. This beetle, however, will also attack and kill healthy young trees during an epidemic, although trees under 15 cm in diameter are seldom attacked. Attacking adults also carry the spores of a blue stain fungus that can invade and block, along with feeding larvae, the conductive vessels of the inner bark and sapwood.

SIMILAR DAMAGE:

May be confused with the mountain pine beetle or secondary beetles. The conspicuous serpentine galleries distinguish the western pine beetle.

IPS BEETLE

Ips spp.

DISTRIBUTION

Throughout BC wherever the host species exists.

Fig 81. Adult. Note: rear concave depression lined with spines.

Fig 82. Egg and larval galleries. Larval galleries radiate from the central nuptial chamber. No frass is present.

TREE SPECIES ATTACKED:

The most critical attacks occur in pole-size to mature lodgepole pine, ponderosa pine, and western white pine.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are reddish-brown to black, often shiny, cylindrical, and about 3 to 6 mm long. An easily recognizable feature of the adult is a pronounced concave depression at its rear end, which is lined on each side with up to six tooth-like spines. The head is not visible when viewed from above.

Adults emerge and begin their attack from mid-May to early June. Pitch tubes are rarely formed or are very small, but fine yellow-red boring dust is usually found in bark crevices. Attack usually advances from the top downward on standing trees. A change in the foliage colour from dark to faded green is usually the first obvious symptom, but the best way to determine if a tree has been attacked by Ips is to remove a piece of bark and examine the tree for evidence of egg galleries. Ips egg gallery patterns consist of a central nuptial chamber from which two or more egg galleries radiate. Larval galleries extend at right angles to the egg galleries and often score the surface of the sapwood, a characteristic that causes some to call the ips "engraver beetles." The galleries are free of boring dust and frass. As the tree or top portion of the tree dies, colour change continues to yellowish-red and then a dull brick red. Two to three generations of beetles may be produced per year; therefore, engraver beetle populations can expand rapidly.

DAMAGE:

Ips beetles usually only attack dead, dying, or damaged trees. They are also often found in the upper portions and on the south sides of trees attacked by the mountain pine beetle, and in conjunction with black-stain fungus. However, heavy populations can build up in windthrow and slash, which can pose a threat to healthy green trees. Ips damage often occurs at the edges of cut blocks.

SIMILAR DAMAGE:

May be confused with mountain pine beetle or other secondary beetles. Ips beetles can be distinguished by the gallery patterns and the distinct shape of the adult.

Fig 83. Larvae brood in a lodgepole pine tree. Ips galleries tend to contain multiple generations.

HYLURGOPS BEETLE

Hylurgops rugipennis (Mannerheim)

DISTRIBUTION

Throughout BC.

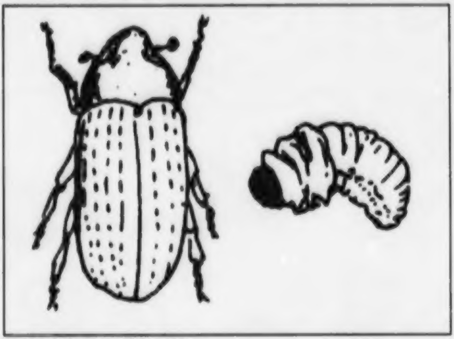


Fig 84. Hylurgops adult and larva

TREE SPECIES ATTACKED:

Pine, spruce, Douglas-fir, western hemlock, and true firs are susceptible. Trees from approximately 15 years old through maturity can be attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adult beetles are reddish-brown and black underneath, growing to 4 to 5 mm in length. They attack stumps and dead, dying, or stressed trees, boring into the bark of the tree at or below the root collar. If the duff is pulled back around the collar of a recently attacked tree, bright orange boring dust is visible at the beetle entrance holes. The adults will occasionally bore into the bole of fallen trees. Attacks occur from spring to the end of summer. Egg galleries extend several centimetres above and below the beetle entrance hole. The larvae mine down from the egg gallery in a large group, so individual galleries are indistinct. As they work down the large lateral roots and the taproot, the larvae separate into smaller groups. The life cycle of the hylurgops beetle takes 1.5 to 2.5 years to complete, depending on when the beetles first attack.

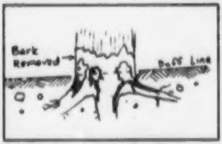


Fig 85. Distribution of galleries on tree.

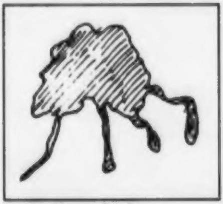


Fig 86. Shape of gallery.

HYLURGOPS BEETLE

DAMAGE:

The hylurgops beetle is considered a secondary beetle, and is not an aggressive killer of healthy trees. It can, however, attack and kill live trees that are stressed.

Fig 87. Beetle galleries at the root collar.

SIMILAR DAMAGE:

Other bark beetles may be confused with the hylurgops beetle. Distinctive features of the hylurgops beetle include attacking only below the root collar, and the large, indistinct galleries formed by gregarious larval feeding. Warren's root collar weevil also attacks below the root collar, but it is distinguished by the presence of tube-like shelters made from pitch and soil that surround the root collar weevil.

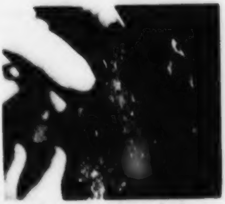


Fig 88. Larval feeding in bark.

Fig 89. Lodgepole pine stand damage by the hylurgops beetle.

Fig 90. Larval galleries.

TWIG BEETLES

Pityogenes spp. / *Pityophthorus* spp.

DISTRIBUTION

Throughout BC where host species are found.

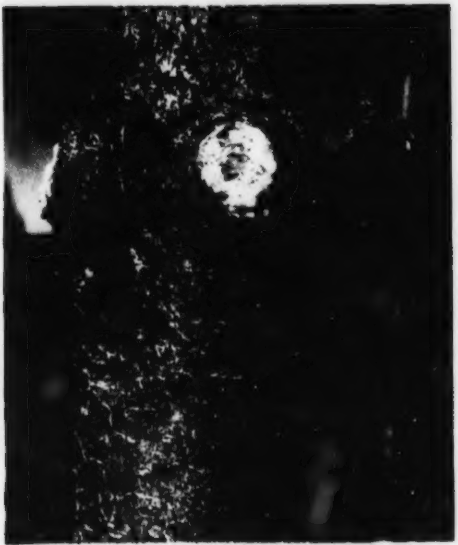


Fig 91. Twig beetle boring dust can be found at entrance holes and caught at the base of the tree or branches.

TREE SPECIES ATTACKED:

Pines are the principal hosts, though a few specific species attack other conifers. Shaded branches on trees of all ages and young trees are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetles are light brown to almost black, and vary in length from 2 to 3.5 mm for the *Pityogenes* to a slightly smaller 1.5 to 3 mm for the *Pityophthorus*. The beetles attack weakened, dying, and newly felled small trees and branches. In young pine trees, they are often found in association with other serious damage agents, such as comandra blister rust and Warren's root collar weevil. Tiny spots of orange-coloured boring dust are visible on the bark at the beetle entrance holes, which are usually plentiful. Several egg galleries, each containing a female, radiate in a star-shaped pattern from a central wood chamber containing one male. The galleries score the sapwood and the inner bark.

Fig 92. Egg gallery scoring the sapwood and inner bark.

DAMAGE:

Populations of twig beetles can build in slash from activities like spacing and pruning. When this occurs, the twig beetle can kill small trees.

SIMILAR DAMAGE:

The plentiful, tiny spots of frass on the bark could be confused with ambrosia beetles, except the colour of ambrosia frass is white, as they bore into the wood rather than the bark.

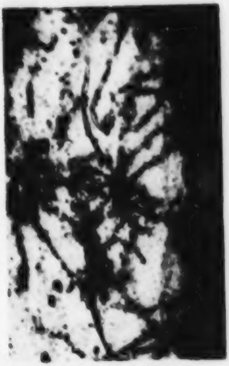


Fig 93. Twig beetle galleries.

FIR ENGRAVER BEETLE

Scolytus ventralis (LeConte)

DISTRIBUTION

Southern BC.

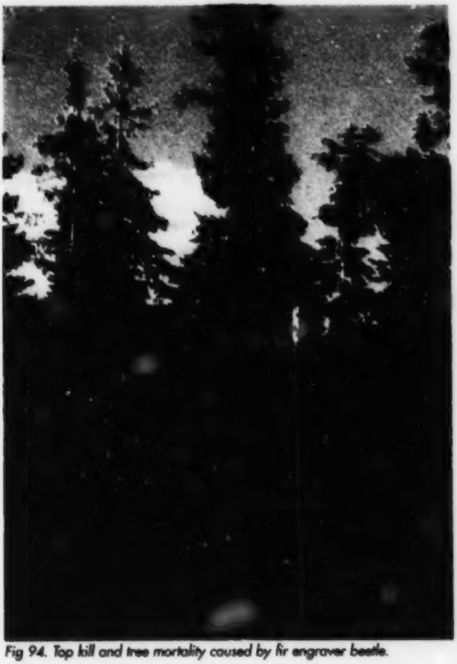


Fig 94. Top kill and tree mortality caused by fir engraver beetle.

TREE SPECIES ATTACKED:

The primary hosts are true firs, though occasionally Douglas-fir and spruce are infected. Trees from pole–size to mature are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetles are shiny, black to reddish-brown, and about 4 mm long. A side view shows that the end of an adult's abdomen is incurved. The beetles bore into the inner bark of trees from June through September, leaving reddish-brown boring dust on the outer bark. The beetles introduce a brown-stain fungus to the sapwood. The galleries the beetles form are very distinctive, in that the egg gallery is constructed horizontally across the grain of the wood for a distance of 5 to 15 cm on both sides of a central entrance chamber. These galleries are deeply scored into the wood. When they hatch, the larvae mine up and down the bole for distances of 13 to 18 cm. The life cycle of the fir engraver beetle is usually completed in one year, though in colder, upper elevations it may take up to two years to complete.

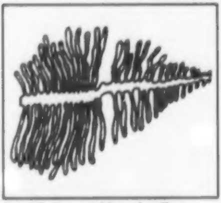


Fig 95. Egg and larval gallery pattern.

DAMAGE:

Trees are often top-killed, can be killed outright if attacked by enough beetles, or may survive repeated attacks for many years. Trees that survive may only be attacked in patches on the bole. Within a patch attack, the cambium is killed and a brown pitch pocket is formed in the wood. These partial attacks are seen externally as roughened patches of bark or scattered dead branches that have been girdled by egg galleries. Trees that are weakened by drought or root disease are particularly susceptible to attack. Populations can build up in slash or windthrow before attacks are made on living trees.

SIMILAR DAMAGE:

May be confused with other bark beetles initially, but the distinct gallery pattern and the deep scoring of the wood differentiates the fir engraver beetle.

RED TURPENTINE BEETLE

Dendroctonus valens (LeConte)

DISTRIBUTION

Throughout BC following the host range.

Fig 96. Large, reddish-brown pitch tubes showing attack sites. Attacks are usually confined to lower 1 m of bole.

TREE SPECIES ATTACKED:

Mature ponderosa and lodgepole pine are attacked. It is infrequently found in other conifers.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult turpentine beetle is the largest in the *Dendroctonus* genus, averaging 8 mm long, and is distinctly reddish-brown. The adults burrow into the lower bole and root collar of a tree, resulting in the formation of large, reddish-brown pitch tubes. The excavated galleries are short, irregular, and usually vertical. The larvae feed in mass formation, which creates a large, fan-shaped gallery. Complete development may take as long as two years in cold areas.

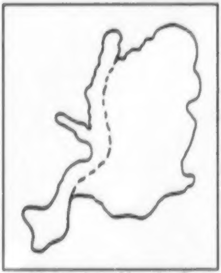


Fig 97. Fan-shaped larval gallery pattern.

DAMAGE:

Like the lodgepole pine beetle, the red turpentine beetle is not an aggressive tree killer. They prefer large, old, weak, or injured trees, and freshly cut logs or stumps. The beetles attack in small numbers, and repeated attacks are required to kill a tree. Trees weakened by turpentine beetle attack are more susceptible to fatal attack by other bark beetles.

SIMILAR DAMAGE:

May be mistaken for other bark beetles, but the large size and the reddish-brown colour distinguishes the adult turpentine beetle. The large, reddish pitch tubes at the base of the tree are similar to the lodgepole pine beetle, but the large cavity mined by the larvae of the turpentine beetle is distinctive.

LODGEPOLE PINE BEETLE

Dendroctonus murryanae (Hopkins)

DISTRIBUTION

Throughout the range of its host.

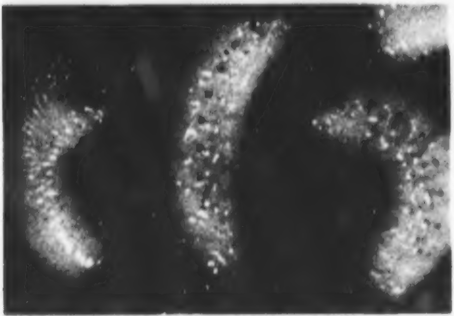


Fig 98. Lodgepole pine beetle larvae. Note the anal shields.

TREE SPECIES ATTACKED:

Mature lodgepole pine is attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetle is 5.5 to 6.5 mm long, dark brown to black, with reddish-brown wing covers. Two anal shields are present on the larvae, which occur on only one other *Dendroctonus* species, the spruce beetle. One generation appears to be completed each year.

Lodgepole pine beetles usually only attack old, injured, or weakened trees; fresh stumps; and windfalls. Occasionally, they will attack more vigorous trees and these attacks are marked by the presence of large pitch tubes and resinous boring dust on the lower bole and root collar. The adults construct short, stout egg galleries. Larval galleries run off from the sides, but they usually run together and become indistinct.

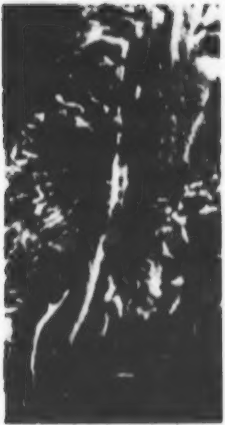


Fig 99. Lodgepole pine beetle egg and larval galleries. Note: larval galleries may run together and become indistinct.

DAMAGE:

This beetle is not an aggressive tree killer like the mountain pine beetle as it tends to mine only in the lower bole and root crown of stressed trees. Occasionally, it will attack and kill old lodgepole pine left standing after timber harvesting. Fortunately, this activity usually involves only a few pairs of beetles and two or more generations may be required to actually kill a tree.

Fig 100. Lodgepole pine beetle pitch tubes on the lower bole of an attacked tree.

SIMILAR DAMAGE:

May be confused with other beetles. Lodgepole pine beetle larvae can be distinguished from other beetle larvae that attack lodgepole pine by the presence of two anal shields. The larval galleries of the lodgepole pine beetle tend to run together and become less distinct than the mountain pine beetle galleries, but they do not mine out as large a cavity as do the red turpentine beetle larvae.

SILVER FIR BEETLE/FIR ROOT BARK BEETLE

Pseudohylesinus grandis / Pseudohylesinus granulatus

DISTRIBUTION

Coastal BC.

Fig 101. Pseudohylesinus spp. adult in gallery.

TREE SPECIES ATTACKED:

Primarily amabilis fir is attacked, but also grand fir, Douglas-fir, and western hemlock.

Fig 102. Fir root bark beetle-killed trees in background; blowdown in foreground.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Fir root bark beetle attacks are usually associated with the silver fir beetle; the biologies of the two species are very similar. The fir root bark beetle attacks the entire bole, though mainly the upper parts, while the silver fir beetle attacks mainly the lower bole. Silver fir beetles (4.1 to 5.5 mm) are larger than fir root bark beetles (2.7 to 3.9 mm). The egg gallery is transverse across the grain of the wood, and resembles that of the fir engraver beetle.

Beetle attack is usually associated with trees that have been stressed. Usually only single trees or a few individual trees are involved.

WHITE PINE WEEVIL

Pissodes strobi (Pk.)

Distribution

Throughout the range of spruce, primarily south of 56 degrees latitude, except the Queen Charlotte Islands.

Fig 103. Larva feeding within spruce leader.

Tree Species Attacked:

Despite its name, the primary hosts for the white pine weevil are Sitka, white, and Engelmann spruce. Pine and other spruce species are sometimes attacked. Trees 1.5 to 10 m high are preferred.

Insect Description & Damage Symptoms:

This insect is also known as the spruce weevil. Larvae are stout, curved, legless grubs. The body is yellowish-white and the heads are light brown. Larvae may reach 1 cm in length by the final instar. Adults are reddish-brown to black with cream markings. Their long, curved snout is characteristic of weevils. Length varies from about 0.5 to 0.8 cm, and the elytra are heavily scaled and mottled in appearance.

Fig 104. Frass plugs along leader indicate egg laying.

The first sign of attack appears in spring, when small punctures appear near the tip of the previous year's leader, where the adults feed and deposit their eggs. Resin droplets are associated with these wounds. The larvae feed gregariously down the leader in the phloem, girdling the stem. Mature larvae excavate cavities in the wood and pith and line them with wood chips. Pupation occurs in these "chip cocoons." By mid-summer, the current year's leader on attacked trees will be distorted and wilted. This shepherd's crook gradually changes from yellow to red to brown, and is indicative of weevil attack. In late summer to fall, large holes made by emerging adults may be seen midway down the previous year's leader. By this time, the current and previous year's leaders are usually dead. Signs of previous attacks include deformed or multiple leaders and dead stubs along main stems. Dead stubs are very crisp, break easily, and contain the distinctive "chip cocoons."

Fig 105. Shepherd's crook is an early indication of attack.

Damage:

This weevil prefers vigorous, open-grown trees, and causes terminal dieback of at least two years' growth. In addition to growing loss, attacks may reduce timber quality by inducing forked and crooked stems. Repeated attacks may allow less desirable species to become dominant over the host species. Secondary organisms such as heartwood rot fungi may enter through the weevil-killed leaders. A severe, lengthy outbreak may reduce stand volume by as much as 30 to 40%. The best time to evaluate damage is from August to September.

Fig 106. Spruce with dead top resulting from earlier attack. Both previous and current year's growth are killed.

Similar Damage:

Frost damage may be confused from a distance with white pine weevil damage. Wind damage can sometimes look like weevil damage when the leaders are young, soft, and flexible. Birds may sometimes break leaders as well. Closer inspection of the terminal will reveal weevil signs, such as adult exit holes, and chip cocoons. Live, newly expanding leaders may droop, causing some confusion between healthy leaders and newly attacked shepherd's crooks.

Fig 107. Exit holes made by emerging adult.

LODGEPOLE PINE TERMINAL WEEVIL

Pissodes terminalis (Hopping)

DISTRIBUTION

Throughout the range of lodgepole pine, south of 50° latitude.

Fig 108. Yellowish-white larva mining leader of lodgepole pine.

TREE SPECIES ATTACKED:

Immature lodgepole pine is attacked, usually from 1 to 10 m in height.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are stout, curved, legless grubs. The body is yellowish-white and the head is brown. The length may reach 1.2 cm in the final instar. Adults are mottled, reddish-brown weevils with a long, curved snout. Their length varies from about 0.4 to 1.0 cm.

Pupae develop in the pith of the terminal shoot. They are white, about the same size and form as the adults, with the long curved snout visible.

Fig 109. Pupa within mined terminal.

The first sign of attack appears in late spring to early summer when small feeding punctures by adults appear at the base of the current year's leader, where the female adult lays her eggs. Resin droplets are associated with these wounds. The larvae then feed on the inner bark, girdling the shoot before migrating into the pith. By mid-summer, the current year's leader is chlorotic. The colour gradually changes from yellow to red to brown. In late summer to fall, large holes made by emerging adults may be seen midway down the current year's dead leader. Signs of attack from previous years include deformed or multiple leaders and dead stubs along main stems. Dead stubs are very crisp, break easily, and are filled with coarse wood particles interspersed with pupal chambers.

Fig 110. Killed and discoloured lodgepole pine leader due to attack. Only current year's growth is destroyed.

DAMAGE:

This weevil prefers the most vigorous, open-grown trees, and causes terminal dieback of the current year's growth. In addition to growth loss, attacks reduce timber quality by inducing forked and crooked stems. The best time to evaluate damage is August to September, when attacked terminals are primarily red. Repeated attacks occurring over several years can result in deformed, multi-leadered trees.

SIMILAR DAMAGE:

Other terminal feeders, frost, and canker diseases can cause terminal death as well. Look for the larvae or pupae in the growing months, and the pupal chambers and adult emergence holes in older attacked stubs.

Fig 111. Fork defect caused by attack. Note the dead stub at the base of the fork.

WARREN'S ROOT COLLAR WEEVIL

Hylobius warreni (Wood)

DISTRIBUTION

Throughout the interior of BC, following the range of its hosts. Optimal conditions for this weevil occur on moist sites with coarse-textured soils and a heavy duff layer.

Fig 112. Larvae are large and creamy white.

Fig 113. Adult.

TREE SPECIES ATTACKED:

Lodgepole pine is the most common host, followed by interior spruce. Usually, only trees over 2 cm in diameter at the root collar are attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are large (up to 2 cm in the final instar), legless, and creamy white. The heads are orange-brown. The flightless adults are typical weevils with a prominent, curved snout. They are 1.0 to 1.5 cm long and thick-bodied, with dull, black-flecked colouring and grey-white scales.

Infested plantations display random mortality of single or small groups of trees. Damaged trees exhibit straw-coloured to deep red foliage starting with the older needles, and stunted terminal growth. Damaged trees are usually easy to push over or have an obvious lean. Positive identification requires careful examination of the tree root collar. During feeding, larvae tunnel into the phloem and cambium and slightly into the wood of the root collar area. Damage is always associated with large quantities of resin mixed with the soil surrounding the damaged roots, which the larvae form into tube–like shelters. This mixture usually feels crunchy if crushed during root collar examination. Pupation occurs at the end of a pitch tunnel sealed off to form a pupal cell.

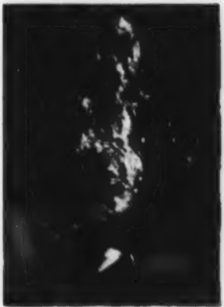


Fig 114. Typical damage to root collar and roots.

DAMAGE:

Larvae are responsible for the majority of the damage. Young trees may be completely girdled at the root collar and die. Older trees are often partially girdled at the root collar, and may be completely girdled around some of the roots; however, no mortality results. Significant damage often occurs when a young stand is located adjacent to an older infested stand, particularly if the young stand opening is small, as the flightless adults usually only move a maximum of 13 m per year. In addition to direct mortality, damaged trees may suffer growth loss and increased susceptibility to root rot, blue-stain fungi, windthrow, and snow press. No pre–weakening of host trees is required for attack, and studies indicate that weevil populations increase as duff depth increases.

Fig 115. Crown symptoms due to girdling.

SIMILAR DAMAGE:

Basal feeding by small mammals such as voles and hares, as well as death due to stem rust or root disease, may be initially confused with Warren's root collar weevil. The tube-like shelters and resin-soaked soil protecting the larvae will distinguish the root collar weevil.

YOSEMITE BARK WEEVIL

Pissodes schwarzi (Hopkins)

DISTRIBUTION

Assumed to be throughout the host range in BC.

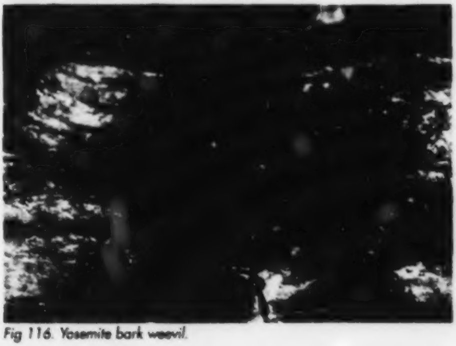


Fig 116. Yosemite bark weevil.

TREE SPECIES ATTACKED:

The primary host is young lodgepole pine, but it has been found in other pines, spruces, and western larch.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adult beetles are rough-surfaced, mottled, reddish-brown to dark brown, 5 to 7 mm in length, and have the distinctive weevil snout. The beetles bore under the bark in the bole, root collar, and large roots of stressed or dying trees. They are commonly found in lodgepole pine affected by serious damaging agents, such as comandra blister rust. Overwintering adults primarily lay their eggs in May through July. The creamy white larvae feed throughout the summer, and overwinter under the bark in distinctive "chip cocoons."

DAMAGE:

Spacing operations can allow Yosemite bark weevil populations to build up in the stumps, at which point they can attack and kill living trees, especially ones that are under stress, such as during drought conditions.

SIMILAR DAMAGE:

Warren's root collar weevil also attacks at the root collar. However, it is a much larger weevil than the Yosemite bark weevil, and has the distinctive pitch tube shelters surrounding it. In contrast, the Yosemite bark weevil larvae create chip cocoons.

Fig 117. Lower bole and root attack of lodgepole pine by the Yosemite bark weevil. Note the distinctive chip cocoons.

CONIFER SEEDLING WEEVIL

Steremnius carinatus (Boh.)

DISTRIBUTION

The coastal and interior wetbelt areas of BC. Primarily the west coast of Vancouver Island and the Queen Charlotte Islands.

Fig 118. Adult. Note rough texture and colour.

TREE SPECIES ATTACKED:

Seedlings of Douglas-fir and Sitka spruce are preferred. Seedlings of hemlock, true fir, and western redcedar are also attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Adults are about 1 cm long, rough-textured, and brick-red in colour when young, becoming brown to yellowish as they age. Adult weevils are most abundant in spring and fall. They feed on a wide variety of plants, including young coniferous seedlings. Damaged seedlings are partially or completely girdled. Injuries usually occur near the root collar but can extend several centimetres up the stem. Girdled seedlings turn yellow or red. Damage can appear randomly throughout an infested area. Attacks are most common on cool, damp sites with an abundance of organic material.

DAMAGE:

This weevil normally feeds on herbaceous species. Girdling of conifer seedlings is usually a problem only on sites where natural ground cover is removed by fire or site preparation prior to planting conifers. Partially girdled seedlings may recover; seedling mortality usually occurs only when seedlings are

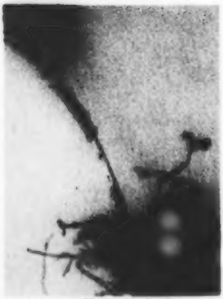


Fig 119. Seedling completely girdled.

completely girdled. Damage is most extensive in first year plantations and is negligible after one growing season. Up to 90% of the seedlings in a plantation can be damaged and mortality rates can be as high as 50%.

Populations of weevils build up for several years in debris left during logging and right-of-way clearing. Thus, attacks usually occur on prepared sites established adjacent to 1 to 3-year old openings. Conifer seedling weevils may act as a vector of black-stain root disease in Douglas-fir.

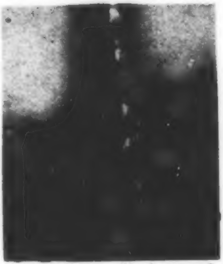


Fig 120. Sections of bark removed from stem.

SIMILAR DAMAGE:

Basal bark damage on seedlings by voles may be confused with conifer seedling weevil damage in areas where distribution of the two pests overlap. Look for signs of vole activity, and indistinct toothmarks in the sapwood. Also, voles feed on larger seedlings, primarily in the winter, whereas conifer seedling weevils attack primarily first year plantations during the growing season.

SEQUOIA PITCH MOTH

Synanthedon sequoiae (Hy. Edwards)

DISTRIBUTION

From the coast to the Rocky Mountains and from central BC to the U.S. border.

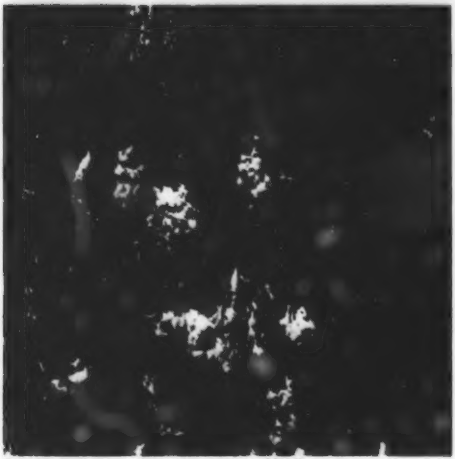


Fig 121. Pitch mass indicating entrance and feeding site.

TREE SPECIES ATTACKED:

The principal host is lodgepole pine, though occasionally other hard pines are attacked, and rarely, Douglas-fir. All sizes of trees over 2 m in height are susceptible.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adults are clear-wing moths with black and yellow bands that make them resemble a yellow–jacket wasp. In June and July, they lay their eggs singly in bark crevices or wounds at any height on a tree's bole or branches. The larvae emerge within two weeks and bore into the inner bark and the outer sapwood, where they feed for two years. The larval mining causes copious flows of soft, white pitch, which has some reddish boring dust mixed in. Old pitch masses turn hard and yellowish. Mature larvae are about 2.5 cm in length, and have reddish–brown heads and an off-white body. Brown pupal skins may be observed sticking out of the pitch masses. Open–grown trees and trees suffering recent wounding (for example, from pruning) are most susceptible to attack.

DAMAGE:

Permanent damage rarely occurs. Occasionally, repeated attacks can girdle and kill young, small-diameter trees or predispose them to breakage. Pitch accumulations are unsightly on trees in recreational areas.

SIMILAR DAMAGE:

Pitch masses on mature trees may be mistaken for beetle-caused pitch tubes. Those of the pitch moth are much larger, and removal of the pitch will reveal the pitch moth. On trees at the very shortest susceptible size range, the northern pitch twig moth may be confused with a first-year sequoia pitch moth. However, the northern pitch twig moth only produces a relatively smooth, small, pitch bubble, unlike the copious flow from the sequoia pitch moth.

Fig 122. Larva within the pitch mass.

NORTHERN PITCH TWIG MOTH

Petrova albicapitana (Bsk.)

DISTRIBUTION

Interior regions of BC following the range of the host species.

Fig 123. Northern pitch twig moth larvae feed singly within a nodule.

TREE SPECIES ATTACKED:

Young lodgepole pine is attacked, generally trees from 0.3 to 3 m tall.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The mature larvae are about 1.7 cm long. The colour of the body varies from yellow to orange-brown. The head is reddish-brown. Characteristic pitch nodules occur near terminal buds, the crotch of branch junctions, or at the crotch of the main stem and branches. These nodules consist of pitch and frass and conceal a single feeding larva in a silk-lined inner chamber. The nodules produced at branch or stem crotches are usually 2.0 cm or more in diameter and are formed by older larvae. Those occurring at terminal buds are usually less than 1 cm in diameter and are produced by newly emerged larvae. The adult moth is a mottled light brown and silver.

DAMAGE:

Feeding larvae can kill the tips of branches or terminal shoots by girdling the inner bark. Occasionally, the nodules on the main stem become large enough to kill the top of a tree. More typically, however, the damaged area is weakened and therefore subject to wind or snow breakage. In

Fig 124. Girdling by northern pitch twig moth larva.

addition, larval feeding may reduce timber quality by inducing crooked leaders. Plantations are more heavily attacked than densely stocked, naturally regenerated stands. This insect rarely attacks suppressed trees.

Fig 125. Breakage and deformity caused by northern pitch twig moth attack.

Fig 126. Northern pitch twig moth feeding often occurs near branch junctions. Trees are subsequently deformed and weakened.

SIMILAR DAMAGE:

On trees over 2 m in height, the sequoia pitch moth can cause similar damage where the two pitch moths overlap in distribution. The mature sequoia pitch moth larvae is larger and lighter in colour than the northern pitch twig moth larvae, and the sequoia pitch moth pitch mass tends to be larger and messier. The gouty pitch midge can cause similar deformities, but will not have the pitch mass associated with the pitch twig moth.

GOUTY PITCH MIDGE

Cecidomyia piniinopis (Osten Sacken)

DISTRIBUTION

Throughout the range of its hosts in BC.

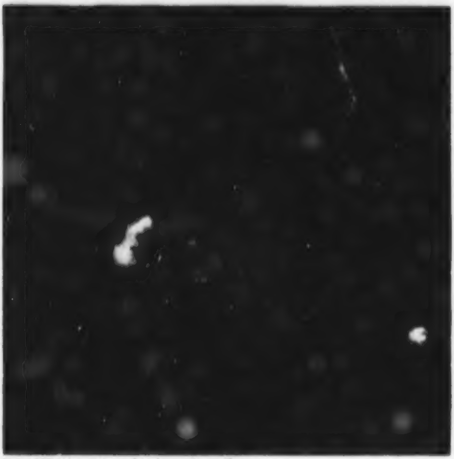


Fig 127. Maggots within branch swellings.

Fig 128. Gouty pitch midge leader damage.

TREE SPECIES ATTACKED:

Primarily young, open-grown ponderosa and lodgepole pines are attacked.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

The adults are small, delicate flies that resemble mosquitoes. Damage is first noticeable in the summer, when fatally attacked new shoots fade in colour, droop, turn yellow, and die. Shoots are often not killed, but may be stunted and twisted, often making a sharp crook at the point of injury. When the bark is removed on the infested tip at the points of slight swellings (gouts), small resinous pockets reveal small, bright orange to red maggots. These maggots overwinter in pits under the bark.

DAMAGE:

Branch tips are stunted or twisted, and may occasionally be killed. When a terminal shoot is attacked, a deformity in the stem can result. Trees 1 to 5 m in height are most often affected.

Similar Damage:

Shoot boring larvae can cause the death or deformity of shoots. Investigation of the pith of the shoot will reveal mining by larvae, which distinguish them from the pitchy gouts just under the bark that indicate the gouty pitch midge.

Introduction to Diseases of Coniferous Trees

Forest diseases are responsible for substantial losses in British Columbia that exceed insect impacts. Wood decay, root diseases, and dwarf mistletoes account for the greatest proportion of these losses. The importance of a particular disease often varies between regions. For example, losses to armillaria root disease are much greater in the interior of British Columbia than on the coast. Conversely, hemlock dwarf mistletoe is a serious coastal pathogen, but is not found in interior hemlock stands. Detailed information on disease distribution can be obtained from the BC Ministry of Forests *Forest Practices Code* forest health guidebooks, and *Distribution Maps of Common Tree Diseases in British Columbia* (Wood, 1986).

Losses in actual and potential wood volume and in wood quality generally occur in a relatively slow and non-cyclical manner, unlike most damage from insect infestations. Forest management practices have a significant long-term effect on whether or not substantial disease impacts develop over a rotation.

Early and accurate disease identification and assessment made through routine field surveys provide the foundation upon which timely and cost-effective treatment decisions can be made.

Diseases result when certain fungi or parasitic plant species gain entry to a host and form host-pathogen relationships, during which the pathogen obtains nutrients and the host is injured.

Many fungi, however, have important roles in forest ecosystems. Fungi perform several valuable functions, including decomposition of dead woody material, formation of symbiotic relationships (mycorrhizae) with tree roots, and food for animals.

Depending on the specific host-pathogen interaction, needle or tip necrosis, wood rotting and/or staining, deformity, and stem/branch cankering subsequently occur. Generalized symptoms are often manifested on areas of the host that do not actually support the pathogen. More specific symptoms are found at the point(s) of infection. An accurate diagnosis should always be based on evidence from signs of the pathogen, such as mycelia, spores, or fruiting bodies. Many fruiting bodies are only formed on older dead tissues one or more years after infection, and may be confused with or obscured by fruiting bodies of saprophytic fungi. Also, fruiting bodies vary widely in size, shape, and colour from minute, powdery, or pimple-like structures (casts, rusts, blights, cankers, and diebacks) to relatively large characteristic mushrooms and conks (root diseases). Accordingly, this section is divided into the following disease groups: root diseases; dwarf mistletoes; branch/stem rusts; branch/stem cankers and diebacks; needle casts, blights, and rusts; and broom rusts.

ROOT DISEASES

Root diseases are caused by several wood–decaying (or staining) fungi. Most trees in British Columbia can be infected. Root disease species fungi are often aggressive pathogens, which can rapidly infect tree roots and root collars, causing death. However, some recent research indicates that some fungi are limited, often substantially, by host tree or environmental factors that prevent or limit infection and damage. Most root disease fungi can survive for several decades as a saprophytic decay in the wood of infected larger trees.

Root diseases primarily spread by root-to-root contact. However, other structures or organisms may also play a role in disease spread, e.g., rhizomorphs (for armillaria root disease), root-feeding bark beetles (for black stain root disease), and spores (for tomentosus root rot and annosus root disease). Injury to the roots or root collar may encourage entry of some of these fungi. However, healthy roots can be infected when they come into contact with infected wood or roots underground.

Most root diseases cause similar crown symptoms. These include chlorosis, reduced terminal leader growth, crown thinning, and distress cone crop. Infected trees may be scattered throughout a stand or may be clumped in noticeable patches called infection centres. A typical infection centre consists of standing infected trees with crown symptoms, standing dead trees, and downed infected trees lying haphazardly. However, accurate identification must be based on host wood decay features, mycelia, or staining in the wood. These root disease features are found by examining the roots and root collar. Fruiting bodies, if present, are also useful for diagnosis. Fruiting bodies of root disease fungi are usually found on the tree host, or in mushroom form on the ground around an infected tree. Comparative identification features are tabulated in the *Forest Practices Code* root disease management guidebook.

ARMILLARIA ROOT DISEASE

Armillaria ostoyae (Romangn.) Herink

DISTRIBUTION

South of approximately 53° latitude.

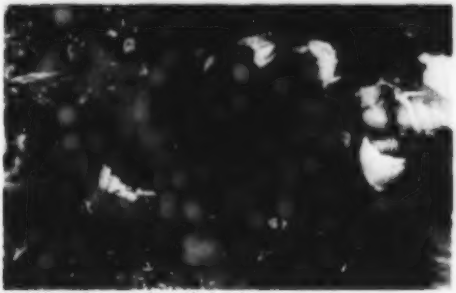


Fig 129. Mushrooms at base of infected tree.

HOST SUSCEPTIBILITY:

Essentially all trees and many woody plant species are susceptible.

SIGNS & SYMPTOMS:

In stands of all ages, armillaria root disease can kill individual trees or cause large centres of mortality. Groups of dead, shade-intolerant conifers may be replaced with shade-tolerant conifers, broadleaved species, or other woody shrubs. Symptoms include chlorotic thinning foliage, reduced shoot growth, and distress cones. Basal resinosis can occur near ground level on resinous hosts. Roots may appear resin-soaked. Advanced decay consists of a yellow, stringy type of rot.

Signs of the fungus may include: white mycelial fans under and within bark of roots and lower bole, rhizomorphs (black shoestring-like structures) on the surface of dead or infected roots, or golden–yellow mushrooms that grow from infected material in the autumn.

DAMAGE:

In coastal forests, armillaria root disease causes obvious mortality on trees to about age 25. In the interior, *Armillaria* kills trees of all ages. It spreads primarily by new host root contact with infected

Fig 130. Resinosis. This symptom is common around the lower bole.

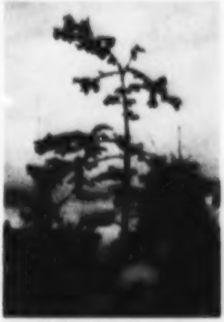


Fig 131. Typical crown symptoms of an immature tree.

roots or rhizomorphs. The probability of infection is influenced by host species, age and vigour of host, site factors (e.g., infection is higher in mesic than dry or wet sites), and presence of inoculum. Some stand management activities have the potential to increase inoculum. Juvenile trees die quickly and show little species-specific resistance, while mature trees die more slowly and exhibit greater host specificity.

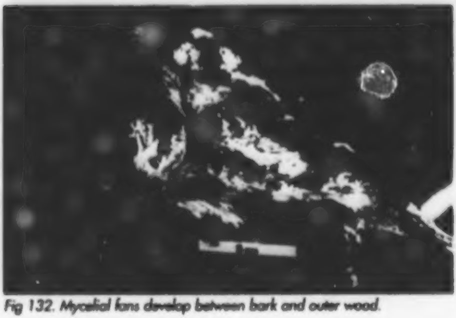


Fig 132. Mycelial fans develop between bark and outer wood.

CAN BE CONFUSED WITH:

Symptoms are similar to other root diseases, bark beetles, and abiotic problems. If mature, standing dead trees exhibit boring dust or bark beetle galleries, check for signs of root disease. However, only armillaria root disease will produce fan-shaped mycelial sheets under the bark. There are other *Armillaria* species (e.g., *A. sinapina*) that act as weak pathogens of stressed trees, or as true saprophytes (non–pathogenic). These secondary invaders can be differentiated from *A. ostoyae* in several ways. They appear on standing dead or down trees, their mycelial fans do not grow in the bark, and they often produce abundant rhizomorphs. *A. ostoyae* rhizomorphs branch dichotomously (forked) while many saprophytic species branch monopodially (right-angled).

LAMINATED ROOT ROT

Phellinus weirii [Murr.] Gilbertson
(possible change to *Inonotus sulphurascens* (Pilat) Carsen et al.)

DISTRIBUTION

Southern interior and coastal BC.

HOST SUSCEPTIBILITY:

Douglas-fir, grand fir, amabilis fir, and mountain hemlock are highly susceptible. Moderately susceptible species include: western hemlock, sub–alpine fir, Sitka spruce, Engelmann spruce, interior spruce, western larch, lodgepole pine, ponderosa pine, and western white pine. Resistant or immune species include western redcedar and broadleaf species.

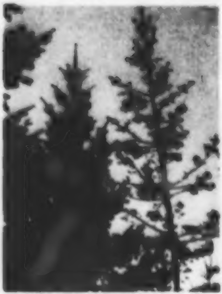


Fig 133. Thin chlorotic crown of immature Douglas-fir.

SIGNS & SYMPTOMS:

Laminated root rot often causes distinct openings (disease centres) in mature stands within which lay randomly-oriented, downed trees with decayed roots. Symptoms include chlorotic thinning foliage, reduced shoot growth, and distress cones.

Laminated root rot causes a red-brown stain followed by the formation of small pits, and finally the delamination of the wood along annual rings. The surfaces between wood layers are often filled with reddish-brown setal hyphae that look like small hairs. Signs include white to mauve ectotrophic mycelia on the surfaces of roots in mineral soil. A dark brown crust forms over the ectotrophic mycelia if they have been exposed to the air. Fruiting bodies are rare and are buff-coloured (turning to brown with age), crust-like layers found on the underside of roots or logs.

Fig 134. Crusty mycelia on surface of bark. Colour varies from white to mauve.

DAMAGE:

Laminated root rot is the most prominent root disease on the coast and also causes significant mortality in the interior. Mortality can occur at all ages. Juvenile trees die quickly. Older trees suffer extensive butt rot leading to increased susceptibility to windthrow and insect attack. This fungus spreads primarily via root contact. The fungus will survive in large stumps for several decades.

Can Be Confused With:

Symptoms are similar to other root diseases, bark beetles, and abiotic problems. If mature, standing dead trees exhibit boring dust and bark beetle galleries, check for signs of root disease. Unlike other root diseases, laminated root rot produces off-white, ectotrophic mycelia on the root surface and a distinct pitted decay that causes delamination along annual rings.

Note:

Western redcedar suffers from a related type of decay attributed to *P. weirii*.

Fig 135. Advanced decay characterized by delamination along annual rings.

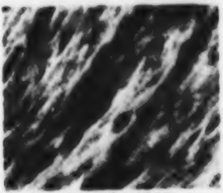


Fig 136. Canoe-shaped pits.

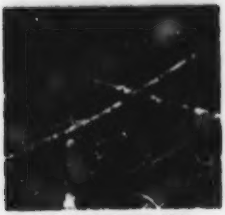


Fig 137. Infection centre. Note crisscross pattern of windthrow and absence of large root mats.

TOMENTOSUS ROOT ROT

Inonotus tomentosus (Fr.:Fr.) S. Teng.

DISTRIBUTION

Throughout BC, particularly in spruce stands of the central and northern interior.

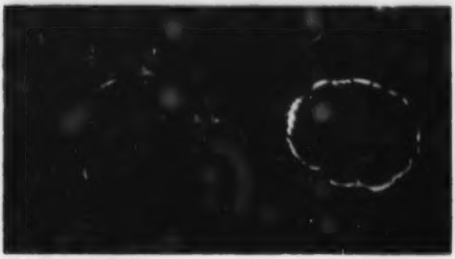


Fig 138. Fruiting bodies.

HOST SUSCEPTIBILITY:

Interior spruce is highly susceptible. Moderately susceptible species include: lodgepole pine, western hemlock, Sitka spruce, Douglas-fir, and sub-alpine fir. Resistant or immune species include western redcedar and broadleaf species.

SIGNS & SYMPTOMS:

Tomentosus root rot often causes small gaps in stand canopies that can coalesce into larger openings, within which lay randomly-oriented, downed trees with decayed roots. Symptoms include chlorotic thinning foliage, reduced shoot growth, and distress cones.

Tomentosus root rot causes a pink to red-brown stain in wood, which progresses to a salmon colour, eventually forming a honeycomb-like, white pocket rot. This pattern progresses from the interior of the root outwards. Decay can be found 1 to 2 m up the bole. Fruiting bodies are produced in the late summer directly from infected roots, and appear as small mushrooms (<10 cm across), which are leathery, velvet topped, and tan to brown, with a porous underside.

Fig 139. Infected young spruce tree. Note distress cone crop and reduced terminal growth.

TOMENTOSUS ROOT ROT

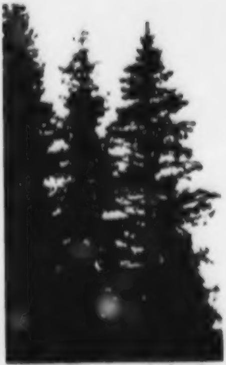


Fig 140. Thin crowns of infected older spruce.

Damage:

Tomentosus root disease is the most prominent root disease in central and northern BC. Juvenile trees die quickly. Older trees suffer extensive butt rot leading to increased susceptibility to windthrow and insect attack. Tomentosus spreads primarily through root contact and can survive in infected large stumps for decades.

Can Be Confused With:

Symptoms are similar to other root diseases, bark beetles, and abiotic problems. If mature, standing dead trees exhibit boring dust or bark beetle galleries, check for signs of root disease. Unlike other root diseases and the decay caused by *Phellinus pini*, tomentosus produces a distinct honeycomb pattern of advanced decay, which is readily apparent in cross-sections of broken roots or stumps.

Fig 141. Cross-section of infected stump.

ANNOSUS ROOT DISEASE

Heterobasidion annosum (Fr.:Fr.) Bref.

Distribution

Throughout BC, particularly in the CWH, CDF, and ICH biogeoclimatic zones.

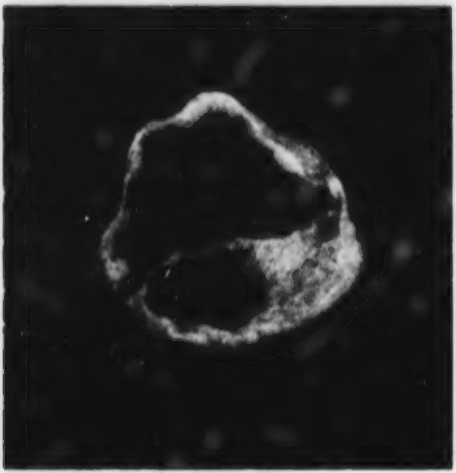


Fig 142. Butt rot. Note colour of incipient decay.

Host Susceptibility:

Annosus root disease comes in two forms: the p-type infects conifers and broadleaf trees, while the s-type affects only conifers. To date, only the s-type has been identified in BC.

Western hemlock, amabilis fir, and Sitka spruce are highly susceptible. Secondary hosts include western redcedar, Douglas-fir, and lodgepole pine. Broadleaf species are immune.

Signs & Symptoms:

Annosus root disease can create small root disease centres. Symptoms include chlorotic, thinning foliage, reduced shoot growth, and distress cones. Signs of annosus include small, cream-coloured pustules on the root surface and conk-like fruiting bodies. Conks are often found on the underside of decayed roots or in crevices at the base of standing dead trees.

ANNOSUS ROOT DISEASE

Fig 143. Resupinate conk of annosus root rot. Fruiting bodies of this disease exhibit small, irregular pores.

Annosus root disease produces a yellow-brown to red-brown stain, which progresses into a white spongy or stringy rot. The decay often contains black flecks running parallel to the wood grain.

Fig 144. Advanced decay symptoms. Black flecks and stringy appearance are distinguishing features.

Damage:

Annosus root rot kills trees of all ages but typically appears as a butt rot on mature trees. Juvenile trees die quickly. Older trees suffer extensive butt rot leading to increased susceptibility to insect attack and wind-throw. This disease spreads both via root contact and by airborne spores, which can invade freshly wounded or cut surfaces. The fungus will survive in large stumps for decades.

Can Be Confused With:

Symptoms are similar to other root diseases, bark beetles, and abiotic problems. If mature, standing dead trees exhibit boring dust or bark beetle galleries, check for signs of root disease. Unlike other root diseases, *Annosus* produces cream-coloured pustules on the root surface and a white, stringy or spongy decay with black flecks.

BLACK STAIN ROOT DISEASE

Leptographium wageneri (Kendrick) M. J. Wingfield

DISTRIBUTION

Southern Interior and coastal BC.

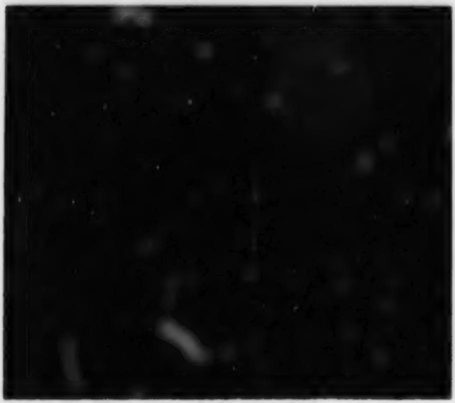


Fig 145. Thin chlorotic crowns of infected Douglas-fir.

HOST SUSCEPTIBILITY:

Two different races of this pathogen are found in BC. Hosts vary depending on the race.

L. wageneri var. *pseudotsugae* is a Douglas-fir type found on the coast and southern interior. The primary host is Douglas-fir.

L. wageneri var. *ponderosum* is a pine type found in the southern interior only. The primary hosts are lodgepole pine, ponderosa pine, western white pine, and spruce.

Fig 146. Crown symptoms of lodgepole pine during advanced stage of infection.

SIGNS & SYMPTOMS:

Black stain root disease occurs on individual trees or small groups of trees. Symptoms include chlorotic, thinning foliage, reduced shoot growth, and distress cones. Black stain is often found in association with other root diseases, such as armillaria root disease and laminated root rot.

There are no external signs of the black stain pathogen. The sapwood of the lower bole or major roots of infected trees has a purple-brown to black stain in long, tapered streaks. *L. wageneri* is not a saprophyte and needs a living host to survive.

Fig 147. Black stain typical of infected sapwood.

DAMAGE:

Black stain can kill trees of all ages. The disease is distinctive because it is spread either by insect vectors or more slowly, and less frequently, via root contact or grafts. The insects carry spores from infected trees to new hosts and make disease spread unpredictable. This spread can be accelerated by activities that cause tree damage or stress, such as road building, partial harvesting, thinning, or pruning.

CAN BE CONFUSED WITH:

Symptoms are similar to other root diseases (especially *Armillaria),* bark beetles (particularly with mature lodgepole pine), and abiotic problems. Look for the distinctive black stain in the sapwood of the lower bole and roots. Although atropellis canker produces a similar stain, it occurs higher on the stem in association with a sunken resinous canker.

RHIZINA ROOT DISEASE

Rhizina undulata (Fr.)

Distribution

Throughout BC, especially on burned areas of the ICH and CWH biogeoclimatic zones.

Fig 148. Seedling killed by rhizina root disease.. Note surrounding lobe-like fruiting structures.

Host Susceptibility:

Seedlings of all native conifer species are susceptible.

Signs & Symptoms:

Rhizina root disease generally occurs one to two years after a wildfire or prescribed fire. Foliage of infected seedlings becomes discoloured, and seedlings are killed. Tan-coloured strands, 1 to 2 mm in diameter, are usually interwoven with the root systems of infected seedlings. Fruiting structures are very distinct, up to 6 cm in diameter, and grow within 50 cm of infected seedlings. They are chestnut to dark brown with many brain-like lobes and fissures. The fruiting bodies often grow in clumps.

Damage:

This pathogen usually occurs in conifer plantations that were burned prior to planting. Seedling mortality may reach 80% on some sites. Moderate to severe outbreaks of the disease have occurred on ICH sites that previously had a stand of decadent western hemlock and western redcedar, and were burned at a moderate intensity. Disease occurrence is slight where sites receive a light burn, such as an early spring burn, or a severe burn where all litter and humus is removed.

CAN BE CONFUSED WITH:

Seedling symptoms are similar to those produced by drought or other root diseases. Fruiting bodies produced in the spring within 50 cm of an affected seedling indicate rhizina root disease. The fruiting body of *Rhizina* is similar in appearance to other ascomycete fungi, such as false morels.

Fig 149. Dying seedling infected. Old fruiting structures are darker in colour.

Dwarf Mistletoes

Dwarf mistletoes are common, perennial, parasitic, flowering plants that derive moisture, nutrition, and support from their host. Generally host-specific, they are very damaging parasites of lodgepole pine, Douglas-fir, western hemlock, and western larch. Other pine species, true firs, and spruce are usually only secondary hosts. Hemlock dwarf mistletoe is restricted to coastal British Columbia. Lodgepole pine, Douglas-fir, and larch dwarf mistletoes are found only in interior British Columbia. Dwarf mistletoes produce distinctive aerial shoots that can be used to identify each species and to distinguish damage from similar injury caused by fungal diseases.

Swellings of the branches and main stem and witches' brooms develop as the dwarf mistletoes grow within host tissue. The characteristic shape and extent of these swellings and witches' brooms depend upon the particular host-parasite relationship. Swellings are pronounced for western hemlock and larch dwarf mistletoes, but may vary on secondary hosts. Witches' brooms are used by birds for nest building, and by small mammals for resting sites.

Tree-to-tree spread of dwarf mistletoe is accomplished by the production of sticky seeds, which are disseminated by forceful ejection from the parent plant. Most seeds land very close to the host; thus, the rate of disease spread is slow. However, 10 widely-spaced, dwarf mistletoe-infected residual trees can infect an entire hectare of new growth within 15 years after establishment, since there is a very high rate of spread from overstory to understory trees. Infection of young trees is correlated with the proximity and height of infected residual trees, stand density, and height of regeneration trees. On some western hemlock sites, trees are only slightly damaged and appear to outgrow the mistletoe. In other situations, especially open-growing interior Douglas-fir stands on poor sites, damage is severe. Moderately (more than 50% of branches infected) to severely infected trees have significantly reduced wood quality and volume.

LODGEPOLE PINE DWARF MISTLETOE

Arceuthobium americanum (Nutt. Ex Engelmann)

DISTRIBUTION

Throughout the range of lodgepole pine, except the BWBS biogeoclimatic zone.

HOST SUSCEPTIBILITY:

Lodgepole pine is the major host. The secondary host is ponderosa pine.

SIGNS & SYMPTOMS:

Infection by lodgepole pine dwarf mistletoe produces either a localized or systemic infection. Infections cause swellings on branches and stems. Aerial shoots arise from these swellings and produce the flowers and seeds of this parasitic plant. Lodgepole pine dwarf mistletoe aerial shoots are perennial, light green, and 3 to 12 cm long. Individual aerial shoots are round in cross-section and branch in a whorled pattern. Systemic infections are often referred to as brooms and, unlike localized infections, produce prolific branching with a characteristic upward sweep. When aerial shoots fall off they leave small, circular structures called basal cups, which persist on the host bark for years. Basal cups on fallen brooms are often the only evidence of lodgepole pine dwarf mistletoe in older stands. Squirrel feeding may be associated with infected branches.

Fig 150. Aerial shoots.

DAMAGE:

Lodgepole pine dwarf mistletoe occurs in most of the range of lodgepole pine except east of the Rockies. Heavily infected trees suffer reduced lumber recovery, reduced height and diameter growth, and occasional mortality. The combined effects of the weight of dwarf mistletoe brooms and the structural weakness produced by the swellings often lead to breakage of both branches and stems. Lodgepole pine dwarf mistletoe infections can result in trees with spiked or dead tops.

Fig 151. Aerial shoots showing green berries, each of which contains a sticky seed.

CAN BE CONFUSED WITH:

Brooms on older trees may have several causes. Elytroderma needle disease can also cause brooms on lodgepole pine. Closely examine brooms or swellings for the presence of basal cups and aerial shoots.

Fig 152. Lodgepole pine on the left is severely infected. Compare distorted crown (left) with healthy crown (right).

HEMLOCK DWARF MISTLETOE

Arceuthobium tsugense (Rosendahl) Jones

DISTRIBUTION

Throughout the coastal range of western hemlock. Not found in the interior.

HOST SUSCEPTIBILITY:

Western hemlock is highly susceptible. Secondary hosts include mountain hemlock, amabilis fir, subalpine fir, shore pine, and Sitka spruce.

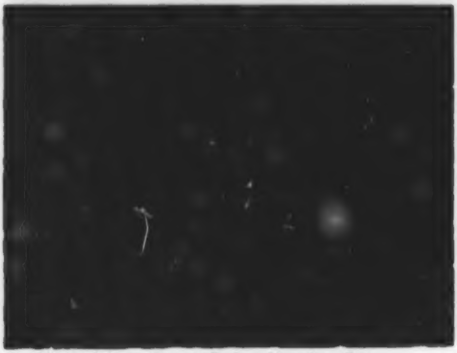


Fig 153. Aerial shoots. Note spindle-shaped branch swelling.

SIGNS & SYMPTOMS:

Infection by hemlock dwarf mistletoe causes swelling and abnormal branching, which results in broom formation. Aerial shoots arise from these swellings and produce the flowers and seeds of this parasitic plant. Hemlock dwarf mistletoe aerial shoots are perennial, light green to brown, and 5 to 12 cm long. When aerial shoots fall off, they leave small, circular structures called basal cups, which persist on the host bark for years. Basal cups on fallen brooms or on dead lower branches, are evidence of hemlock dwarf mistletoe in older stands.

Fig 154. Swelling on bole of western hemlock caused by dwarf mistletoe.

DAMAGE:

Hemlock dwarf mistletoe is widespread throughout the range of coastal western hemlock. The disease is not found in interior western hemlock stands. Heavily infected trees suffer reduced lumber recovery, reduced height and diameter growth, and occasional mortality. The swellings caused by dwarf mistletoe can create an infection court for decay fungi. The combined effects of the weight of dwarf mistletoe brooms and the structural weakness produced by the swellings often lead to breakage of both branches and stems.

CAN BE CONFUSED WITH:

Mature and over-mature coastal western hemlock trees often have an abundance of gnarled, swollen branches. It is easy to confuse these with the brooms and swellings caused by hemlock dwarf mistletoe. Fallen, swollen branches under such trees should be examined for the presence of basal cups. Confirmation of overstory infection requires evidence from fallen brooms or infections on understory trees.

Fig 155. Typical witches' brooms resulting from prolonged infection.

LARCH DWARF MISTLETOE

Arceuthobium laricis (Piper) St. John

DISTRIBUTION

Throughout the range of western larch.

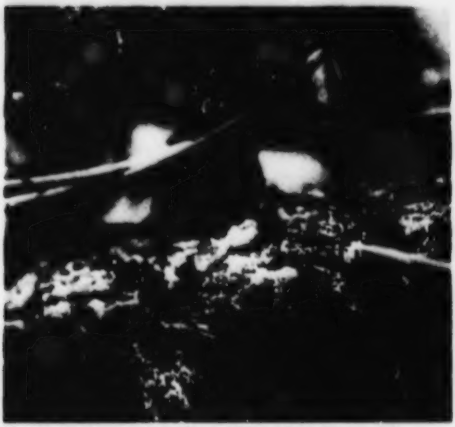


Fig 156. Basal cups remain after aerial shoots have disintegrated.

HOST SUSCEPTIBILITY:

Western larch is the major host. Moderately susceptible species include lodgepole pine, western white pine, and grand fir.

Fig 157. Branch swelling and aerial shoots.

SIGNS & SYMPTOMS:

Infection by larch dwarf mistletoe produces a localized infection, which causes swellings on branches and stems. Aerial shoots arise from these swellings and produce the flowers and seeds of this parasitic plant. Larch dwarf mistletoe aerial shoots are perennial, light green to purple, and 2 to 12 cm long. Individual aerial shoots are square in cross-section and branch in a fan-like pattern. Brooms are formed as a result of prolific branching by the host. When aerial shoots fall off they leave small, circular structures called basal cups, which persist on the host bark for years. Basal cups on fallen brooms are often the only evidence of larch dwarf mistletoe in older stands. Squirrel feeding may be associated with infected branches.

LARCH DWARF MISTLETOE

DAMAGE:

Larch dwarf mistletoe occurs in most of the range of western larch in the southern interior. Heavily infected trees suffer reduced lumber recovery, reduced height and diameter growth, and mortality. The swellings caused by dwarf mistletoe often lead to infection by decay fungi. The combined effects of the weight of dwarf mistletoe brooms and the structural weakness produced by the swellings often lead to breakage of both branches and stems. Larch dwarf mistletoe infections can result in trees with spiked or dead tops.

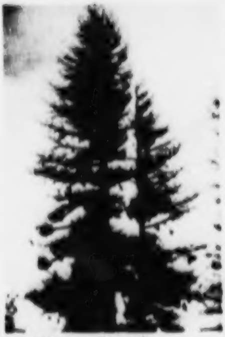


Fig 158. Typical upright witches' brooms

CAN BE CONFUSED WITH:

Older or veteran western larch can develop brooms formed by adventitious buds and branches. Fallen, swollen branches under such trees should be examined for the presence of aerial shoots or basal cups. Larch dwarf mistletoe can infect lodgepole pine when the hosts occur on the same sites. Individual lodgepole pine dwarf mistletoe aerial shoots are round in cross-section and branch in a whorled pattern. Large brooms are never formed by larch dwarf mistletoe on lodgepole pine.

Fig 159. Infection showing thin crown and deformity. Tree vigour is greatly reduced.

DOUGLAS-FIR DWARF MISTLETOE

Arceuthobium douglasii (Engelmann)

DISTRIBUTION

A limited extent in the southern interior range of Douglas-fir.

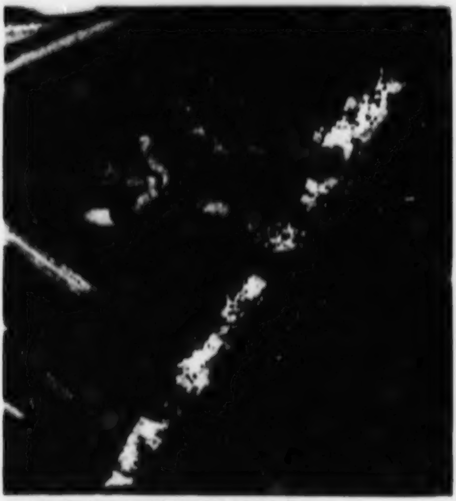


Fig 160. Developing aerial shoots on Douglas-fir.

HOST SUSCEPTIBILITY:

Douglas-fir is highly susceptible, and grand fir is moderately susceptible.

Fig 161. Drooping branch due to heavy infection.

SIGNS & SYMPTOMS:

Infection by Douglas-fir dwarf mistletoe causes sewlling and abnormal branching, which results in broom formation. Very small aerial shoots arise from these swellings and produce the flowers and seeds of this parasitic plant. Douglas-fir dwarf mistletoe aerial shoots are perennial, olive-green, and about 2 cm long. Large, pendulous brooms are formed as a result of prolific branching. When aerial shoots fall off, they leave small, circular structures called basal cups, which persist on the host bark for years. Basal cups on fallen brooms are evidence of Douglas-fir dwarf mistletoe in older stands.

DOUGLAS-FIR DWARF MISTLETOE

Damage:

Douglas-fir dwarf mistletoe occurs only to a limited extent in the southern range of Douglas-fir east of the Cascades. Heavily infected trees suffer reduced lumber recovery, reduced height and diameter growth, and mortality. The combined effects of the weight of dwarf mistletoe brooms and the structural weakness produced by the swellings often lead to breakage of both branches and stems. Douglas-fir dwarf mistletoe infections can result in trees with spiked or dead tops.

Can Be Confused With:

No other dwarf mistletoe occurs on Douglas-fir.

Fig 162. Severely deformed crown resulting from extensive infection.

BRANCH AND STEM RUSTS

Pine and alternate host species, such as currants and gooseberries (*Ribes* spp.), are infected. All branch and stem rusts, with the exception of western gall rust, require these herbaceous alternate hosts for completion of the life cycle.

Aerial invasion of the pine host, by means of fungal spores, leads to the formation of blister-like cankers or galls on the main stem or branches, primarily in the first 2 m of tree height, if conditions are favourable. As a result, stems and branches are prone to breakage, and trees can be weakened or killed due to girdling of the stem by continued canker growth and invasion by secondary insects (*Dioryctria* spp.).

Noticeable disease symptoms appear two to three years after spores have infected the pine host. Discolouration and progressive swelling of the bark becomes apparent, followed by the formation of spore blisters in the spring. Further spread occurs by these powdery spores, which are white, yellow, or orange, and are very apparent. Evidence of animal feeding, roughened bark, and copious resin flow are often seen around the cankers. Tentative identification of branch/stem rust species is possible in the field based on the shape of stem or branch infections. However, microscopic examination of the spores is often required for a definitive identification.

COMANDRA BLISTER RUST

Cronartium comandrae (Peck)

DISTRIBUTION

Throughout BC, especially the SBS biogeoclimatic zone.

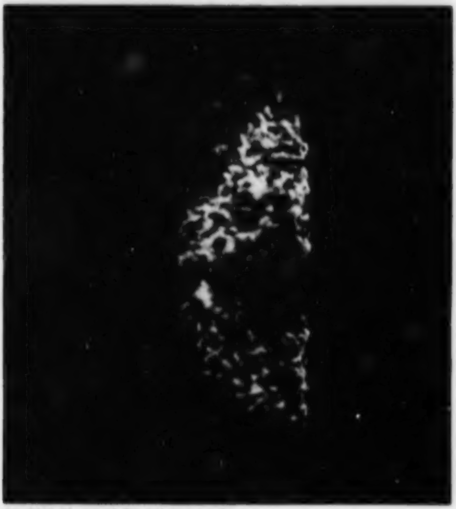


Fig 163. Diamond-shaped stem canker.

HOST SUSCEPTIBILITY:

The primary hosts are 2- and 3-needle pines, including lodgepole and ponderosa pine. Alternate hosts include *Comandra* spp. or *Geocaulon* spp., primarily bastard toadflax (*G. lividum*).

SIGNS & SYMPTOMS:

Comandra blister rust is primarily a disease of young lodgepole pine. The fungus is an obligate parasite and the host often does not show crown symptoms until just before death. Most stem cankers are lethal, occuring within 1 m of the ground and often beginning as branch infections. Branch cankers appear as blunt-ended swellings that girdle the branch, whereas stem cankers are oval or diamond-shaped. For most of the year cankers are inconspicuous. In the spring, blisters appear and release orange spores, which infect the alternate host. Spores returning from the alternate host infect pine needles in the late summer. Lower branches should be carefully inspected for cankers.

Damage:

Most tree mortality occurs between ages 5 and 30. The uneven distribution of mortality often leads to stand gaps. Squirrels commonly feed on cankers and may hasten host mortality. On ponderosa pine, infection occurs on trees of all ages. Spike tops on older trees result when live crown exists below the canker.

Can Be Confused With:

Comandra blister rust can be confused with atropellis canker and other pine stem rusts, such as sweet-fern blister rust and stalactiform blister rust. Comandra branch cankers are blunt-ended, whereas stalactiform cankers are narrow, elongated, and pointed. Comandra stem canker height is only 1.5 times the width (diamond–shaped), whereas stalactiform canker height is at least 10 times the width (elongated). Atropellis cankers are never fed upon by squirrels and contain black-stained wood directly beneath the canker.

Fig 164. Canker girdling host stem. Note white blisters, which contain yellow-orange spores.

Fig 165. Rough bark and resin flow are associated. Note swollen bark at canker margin.

STALACTIFORM BLISTER RUST

Cronartium coleosporioides (Arthur)

DISTRIBUTION

Throughout BC.

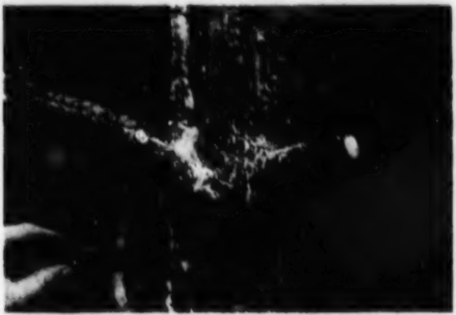


Fig 166. Blisters contain orange spore masses. Note stripped bark due to squirrel feeding.

HOST SUSCEPTIBILITY:

The primary hosts are lodgepole and ponderosa pine. Alternate hosts include Indian paintbrush (*Castilleja* spp.) and other species of the figwort family(*Scrophulareacea*).

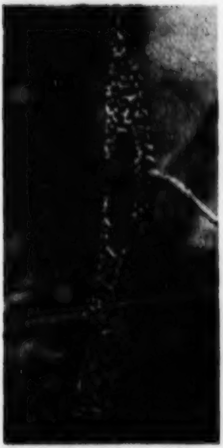


Fig 167. Elongated stem canker.

SIGNS & SYMPTOMS:

Trees of all ages can be infected but mortality occurs primarily on small or slow-growing trees. The fungus is an obligate parasite and the host often does not show crown symptoms until just before death. The disease causes a bark canker which is often lethal when located on the stem. Cankers appear as elongated swellings that slowly girdle the branch or stem. Cankers are diamond-shaped and typically 10 times higher than wide. Stem cankers can be several metres in length. In the spring, blisters appear and release orange spores which infect the alternate host. Spores returning from the alternate host infect pine needles in the late summer.

DAMAGE:

Mortality occurs rapidly on very young trees. Due to the slow growth of stalactiform cankers, large infected trees will survive to a commercial thinning or harvest but will suffer increment loss and reduced wood quality. Canker edges are often fed upon by squirrels. Repeated feeding on cankers can result in a striated pattern of bark stripping. Spike tops on older trees result when live crown exists below the canker.

Fig 168. Branch canker infection.

CAN BE CONFUSED WITH:

Stalactiform blister rust can be confused with atropellis canker and other pine stem rusts, such as sweet-fern blister rust and comandra blister rust. Stalactiform branch cankers are narrow, elongated, and pointed, whereas comandra cankers are blunt-ended. Stalactiform canker height is at least 10 times the width (elongated), whereas comandra stem canker height is only 1.5 times the width (diamond-shaped). Atropellis cankers are never fed upon by squirrels and contain black-stained wood directly beneath the canker.

WESTERN GALL RUST

Endocronartium harknessii (J.P. Moore) Y. Hiratsuka

DISTRIBUTION

Throughout BC.

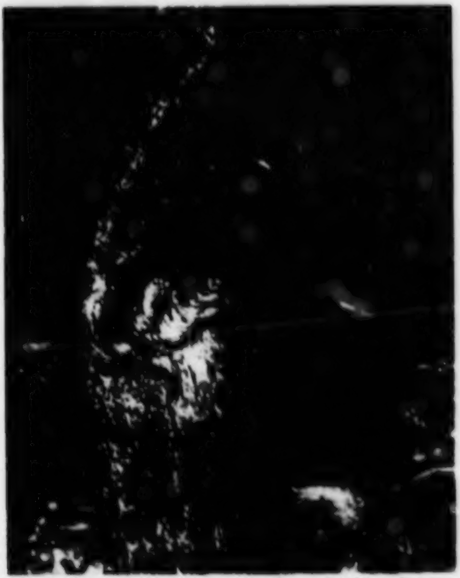


Fig 169. Infections on stems of young trees often result in hip cankers as the trees grow.

HOST SUSCEPTIBILITY:

Highly susceptible species are lodgepole and ponderosa pine.

SIGNS & SYMPTOMS:

Western gall rust produces round woody swellings on stems and branches. Orange spores are produced on galls in late spring. These spores directly infect other pines through elongating leaders and branch shoots. Suitable climatic conditions that occur every few years result in "wave years" of infection. The fungus is an obligate parasite and remains alive as long as the host branch or stem. However, infections stop releasing spores after about age 10. Most stem

Fig 170. Symptoms resulting from complete girdling.

infections occur below a height of 3 m. Hip cankers result in distorted growth from partial stem girdling. Infected bark can be fed upon by squirrels.

Fig 171. Lodgepole pine with multiple galls.

Damage:

Western gall rust is very common throughout the range of lodgepole pine. Stem galls often lead to mortality either through girdling or through stem breakage. Branch galls do not cause serious harm. The disease is usually more evenly distributed throughout stands than blister rusts, which require an alternate host.

Can Be Confused With:

Small galls can be confused with *Comandra* infections, particularly when spores are present. Gall rust produces distinct woody swellings while blister rusts do not.

Fig 172. Old stem gall. Note rough surface of bark.

WHITE PINE BLISTER RUST

Cronartium ribicola (J.C. Fisch.)

DISTRIBUTION

Throughout the range of 5-needle pines.

Fig 173. Yellowish-orange bark discolouration precedes formation of cankers.

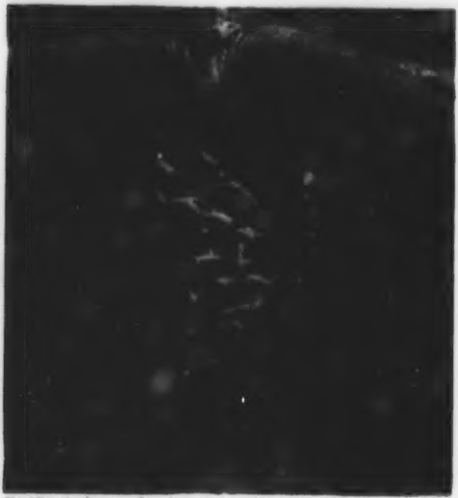


Fig 174. Cankers are found on stems and branches. Note diamond shape.

Fig 175. Infections are characterized by rough, swollen bark.

HOST SUSCEPTIBILITY:

Primary hosts are western white, limber, and whitebark pine. Alternate hosts include most species of *Ribes* (currants and gooseberries).

SIGNS & SYMPTOMS:

Trees of all ages can be infected but mortality occurs most rapidly on juvenile trees. This non-native fungus is an obligate parasite and only occurs on 5-needle pines. The disease causes a bark canker which is lethal when located on the stem. Cankers begin as yellow-orange swellings and typically develop a diamond shape. Most stem cankers occur within 2 m of the ground and often begin as branch infections. Branch infections often produce a characteristic red flagging. In the spring, blisters appear and release orange spores which infect the alternate host. Spores returning from the alternate host infect pine needles in the late summer. Lower branches should be inspected even into the duff layer.

DAMAGE:

This introduced disease has severely damaged 5-needle pines throughout its range. It has essentially removed western white pine from use in reforestation and threatens to eliminate whitebark pine from high elevation sites. Stand hazard is related to the local abundance of *Ribes* spp. Spike tops on older trees result when live crown exists below the canker. Spike tops are common on steep slopes where air drainage carries spores into the upper canopy.

Fig 176. Developing canker. Note shape, colour, and resin flow.

CAN BE CONFUSED WITH:

White pine blister rust occurs only on 5-needle pines and cannot be confused with anything else. White pine mortality can be confused with armillaria root disease (look for mycelial fans under bark at the tree base), mountain pine beetle (look for boring dust and distinctive galleries under bark), and sunscald (look for slightly sunken areas of dead cambium). A drought-caused condition called pole blight has also caused white pine mortality, especially in the southern interior, but this damage has not been reported for several years.

Fig 177. Top-killed white pine.

BRANCH/STEM CANKERS & DIEBACKS

All native conifers are susceptible to one or more species of fungi that cause branch/stem cankers and diebacks. The most obvious symptom is the presence of cankers or diseased areas on the stem or branches, formed after invasion of the host bark by a fungal pathogen. Although both healthy and stressed trees can be attacked, most canker diseases, such as dermea canker, phomopsis canker, and sydowia tip dieback, are associated with conditions of drought or frost stress in younger trees.

Generally, cankers are elongate to oval and sunken in the centre. Bark of the canker becomes discoloured and necrotic, and often sloughs off, leaving exposed sapwood, which may or may not be stained. Small, black, disc-like or pimply fruiting bodies are often seen on the canker face. Cankers are often distinctive in appearance, depending upon the fungi and hosts involved. However, fruiting bodies and spores have to be examined microscopically to confirm identity of the fungal pathogen. In most instances, collections of cankers should be submitted to substantiate the damage and confirm the pathogen.

Resinosis is also common around cankered areas. Cankers are either annual or perennial, according to species. Cankers that form annually are generally less damaging. They are smaller and flatter than perennial cankers, which grow in size from one year to the next. Atropellis canker, an example of a perennial canker, causes mortality and growth reduction, particularly in dense pine stands. Annual cankers, such as dermea canker, typically cause only branch or leader dieback and subsequent growth loss with extensive infections; mortality is usually restricted to severely stressed trees.

ATROPELLIS CANKER

Atropellis piniphila (Weir) Lohman and Cash

DISTRIBUTION

Throughout BC.

HOST SUSCEPTIBILITY:

Lodgepole pine is highly susceptible. Ponderosa pine is also susceptible.

SIGNS & SYMPTOMS:

Atropellis canker is most commonly found anywhere along the bole below the live crown. The canker appears as an elongated, resinous depression. Small black fruiting bodies (apothecia) form on dead bark in the center of the canker. A characteristic blue-black stain below the canker is readily evident. The area of stain is usually wedge-shaped in cross-section and often penetrates deeply towards the pith.

DAMAGE:

Dense stands may experience mortality, especially of suppressed individuals. Multiple cankers can cause the mortality of older stems; the cankers can also serve as points of weakness for stem breakage. Reduced lumber recovery of cankered stems is significant. Staining, resin-soaked sapwood, and loss of bending strength result in lower wood quality.

CAN BE CONFUSED WITH:

Stalactiform blister rust and other cambium damaging agents (e.g., sunscald) can produce similar symptoms. Atropellis cankers can be distinguished by the black stain underlying the canker. Animal feeding does not occur on atropellis cankers, unlike squirrel feeding on rust cankers.

Fig 178. Blue-black stain in wood underneath.

Fig 179. Canker developing on lodgepole pine. Note elongated shape and resin flow at canker margin.

Fig 180. Large, sunken cankered area. Main stem is significantly weakened.

DERMEA CANKER

Dermea pseudotsugae (Funk)

DISTRIBUTION

Throughout BC following the host range.

Fig 181. Douglas-fir killed due to girdling by Dermea canker.

HOST SUSCEPTIBILITY:

Douglas-fir is susceptible, primarily seedlings and saplings.

SIGNS & SYMPTOMS:

Dead tops and branches result from canker girdling. Needles on affected areas turn red and are shed a few months later. Infections on the stem mainly occur at branch bases and appear as patches of necrotic bark, which have a reddish margin and are sunken. The bark covering the cankers eventually dries, cracks, and is sloughed off. Secondary infections may result in cankered areas. Small, black, fruiting structures may be present on the surface of cankers. A small bark beetle is often associated with the cankers.

Fig 182. Sapling showing reddish discolouration of bark.

DAMAGE:

This disease has the potential to cause widespread mortality in young Douglas-fir stands. However, it is usually associated with adverse weather conditions such as early frost.

CAN BE CONFUSED WITH:

Phomopsis cankers are similar, but the conspicuous reddish margin on the dermea canker is distinctive.

PHOMOPSIS CANKER OF DOUGLAS-FIR

Diaporthe lokoyae (Hahn)

DISTRIBUTION

Lower Mainland and Vancouver Island; infrequently found in southern interior.

HOST SUSCEPTIBILITY:

Primarily seedlings and saplings of Douglas-fir are susceptible, and occasionally western hemlock and western redcedar.

Fig 183. Elliptical shape and sunken tissue are typical. Note dead twig in centre of canker.

SIGNS & SYMPTOMS:

Stem and branch cankers, which may cause dead branches and top dieback, result from infection. Cankers are elliptical and sunken, usually several times longer than they are wide, and commonly have a dead twig or branch near the centre. Small (0.5 mm), black, fruiting bodies cover the canker surface in spring and early summer. Tree foliage above girdled stems or branches turns red.

DAMAGE:

Outbreaks are usually limited to single or small groups of trees. Cankers survive only one year, although small trees are often girdled, with resultant mortality. Affected areas heal over on surviving trees, in much the same way an axe wound heals. Larger trees usually survive infections although branches or tops may be killed. Infections usually follow stress caused by drought or frost.

Fig 184. Mortality due to complete stem girdling.

CAN BE CONFUSED WITH:

Dermea cankers are similar, but no conspicuous reddish margin is present on the phomopsis canker.

RED FLAG DISEASE

Potebniamyces balsamicola (Smerlis)

DISTRIBUTION

Throughout BC.

Fig 185. Branch flagging is a typical symptom.

HOST SUSCEPTIBILITY:

True firs are the major hosts.

SIGNS & SYMPTOMS:

Red flag disease causes reddish-brown branch flagging, dead branches, and leader dieback due to formation of annual cankers. On the stem, cankers

Fig 186. Cracked bark covering cankers.

are elliptical, sunken, reddish-brown patches on the bark. Cankers are usually resin-soaked, and small, black, fruiting structures are visible on the bark surface. Killed bark remains attached, eventually cracking and sloughing off.

DAMAGE:

Generally, losses to this disease are small. Mortality is usually limited to seedlings since these cankers are annual and rarely girdle larger trees. Cankers heal completely in most cases, although there is a chance that secondary infections may occur.

SYDOWIA TIP DIEBACK

Sclerophoma spp.

DISTRIBUTION

Throughout BC.

Fig 187. Dead branches of an infected immature Douglas-fir tree.

Fig 188. Healed stem canker.

Fig 189. Black fruiting bodies on necrotic bark surface (magnified).

HOST SUSCEPTIBILITY:

All native conifers are susceptible, primarily seedlings and saplings.

SIGNS & SYMPTOMS:

Infected trees suffer dieback of leaders and branches. There is often a swelling at the margin of the necrotic and healthy tissue. Small, black, fruiting structures are produced and are found embedded in the bark of the dead portion of the tree.

DAMAGE:

This disease is common on trees stressed by drought, late frost, or other factors, such as being planted on an unsuitable site. Young trees are damaged the most, often resulting in dead tops or mortality.

NEEDLE CASTS, BLIGHTS, & RUSTS

Needle casts and blights are fungal diseases that kill trees or cause premature loss of needles from coniferous trees. All conifers in British Columbia are attacked by some type of needle cast or blight. Some, such as the pines, are attacked by many needle casts, blights, or rusts, and other trees, such as western redcedar, are attacked by few.

Needle rusts are common to all conifers in British Columbia. They have complex life cycles that usually involve an alternate host, which may be a fern, flowering plant, or shrub. Needle rusts are most visible in the spring when easily recognizable fruiting structures are produced on the needles of coniferous hosts. These are typically blister-like sacs filled with white to orange spores.

Most infections occur on young trees or on the lower branches of older trees. Infections are confined to individual needles, which usually die and are cast. Outbreaks of needle casts and blights fluctuate greatly from year to year, depending mostly on weather conditions that affect spore production, release, and germination. Damage from these diseases varies from growth reduction or mortality of younger trees to no apparent effect on older trees. Many species of needle cast, blight, and rust fungi infect the conifers of British Columbia. However, only those that are most common or likely to cause significant damage are described.

CEDAR LEAF BLIGHT

Didymascella thujina (Durand) Maire

DISTRIBUTION

Throughout BC, following the range of western redcedar.

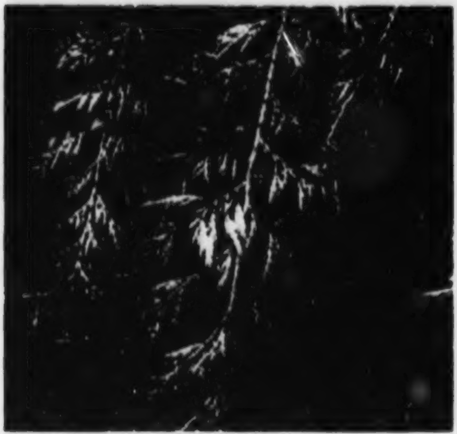


Fig 190. Infected western redcedar branchlets.

HOST SUSCEPTIBILITY:

Western redcedar is the primary host. All ages are susceptible, but it is most prevalent on young seedlings and the lower branches of older trees.

SIGNS & SYMPTOMS:

Infected leaves turn reddish-brown over the summer. The infected leaves are usually conspicuous against healthy green foliage. In fall, some infected leaf twigs are shed. Older twigs still attached to the branch become ashy grey. Small black cavities will be found on the upper surfaces of infected leaves. These holes are left after the fruiting bodies dry up and fall out. Dense stands growing on wetter sites are most affected.

Fig 191. Holes left by fruiting bodies.

DAMAGE:

Overall losses from this disease are low, although seedlings and saplings may suffer mortality. Older trees may exhibit growth reduction, dead branches, and rare mortality. High densities and high humidity in forest nurseries are ideal for this disease, where it can be a serious problem.

Can Be Confused With:

Cedar leaf blight can be confused with normal autumnal colour changes. However, seasonal colour changes affect the entire tree as opposed to the scattered twigs affected by cedar leaf blight. The holes remaining in the leaves after the fruiting bodies fall out can be mistaken for insect feeding punctures. Cedar flagging affects scattered branches in a similar fashion, but the black fruiting bodies or holes left from them are not present.

Fig 192. Developing fruiting structures.

LARGE-SPORED SPRUCE LABRADOR TEA RUST

Chrysomyxa ledicola (Lagerh.)

DISTRIBUTION

Throughout BC.

Fig 193. Infection is restricted to new foliage.

Fig 194. White blisters on current year's needles. Note chlorosis around blisters.

HOST SUSCEPTIBILITY:

All native spruce species of all ages are susceptible.

SIGNS & SYMPTOMS:

The current years' needles, and occasionally cone scales, develop prominent white blisters filled with bright orange spores throughout the summer. The areas on the needle where blisters originate are chlorotic and contrast with the remaining healthy green portions.

DAMAGE:

The current year's needles may be almost completely defoliated. Growth loss may result, but mortality is rare. This rust is most severe adjacent to bogs where the alternate host (Labrador-tea) is found, and during periods of moist weather.

SPRUCE NEEDLE CAST

Lirula macrospora (Hartig) Darker

DISTRIBUTION

Throughout the range of spruce in BC.

Fig 195. Black, elongated fruiting bodies. Killed needles are retained.

HOST SUSCEPTIBILITY:

All ages of all native spruce species are susceptible.

SIGNS & SYMPTOMS:

This pathogen has a two-year life cycle. Infected needles become straw or brown-coloured and die. Killed needles remain on twigs longer than naturally senescent needles. Elongated, black fruiting bodies are found on dead needles. Spruce needle cast becomes infectious to spruce every second year; therefore, tree foliage may have every second year's growth affected. Infections are more common in the lower crown.

Fig 196. Spruce needle cast infection of previous year's growth.

DAMAGE:

Successive years of severe infection may cause growth reduction; however, this is uncommon. Usually, there is only localized damage. Mortality seldom occurs.

SIROCOCCUS TIP BLIGHT

Sirococcus strobilinus (Preuss)

DISTRIBUTION

Coastal BC.

Fig 197. Branch dieback. Note shepherd's crook at tip.

HOST SUSCEPTIBILITY:

All ages of western hemlock, spruce, and pines are susceptible. Other conifers are very rarely attacked.

SIGNS & SYMPTOMS:

The current year's needles on the terminal and lateral tips become brown. Shoots eventually die, at which time small purplish cankers should be visible on the stem. Dead tips are usually curled back into a shepherd's crook. Small, black fruiting bodies may be visible on dead stems or needles. Infection is usually restricted to the current year's growth.

SIROCOCCUS TIP BLIGHT

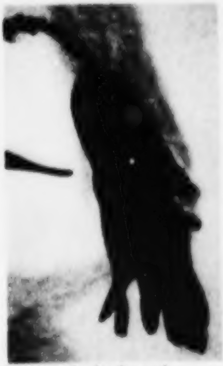


Fig 198. Shepherd's crook. Note small, black fruiting bodies.

Damage:

This disease is more common in dense regeneration, or stands where low light and high moisture conditions prevail. Under these conditions, seedlings and young trees may suffer mortality as a result of multiple infections. Severe infection on older trees may cause growth reduction, but not mortality. Damage from this disease is generally light.

Can Be Confused With:

Damage caused by a late frost may appear similar, but the small, black fruiting bodies distinguish sirococcus tip blight.

WESTERN PINE-ASTER RUST

Coleosporium asterum (Diet.) Syd.

DISTRIBUTION

Throughout the host range in BC.

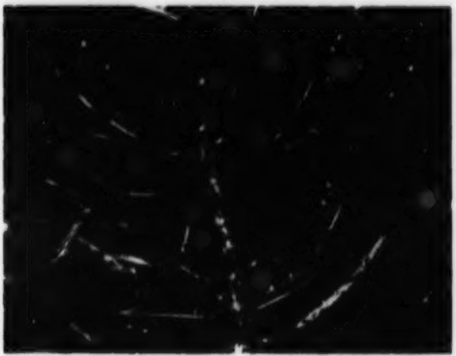


Fig 199. Needle discolouration produced by infection of older needles. Note spore-bearing white blisters.

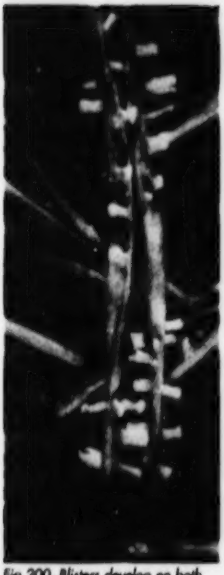


Fig 200. Blisters develop on both sides of the needles.

HOST SUSCEPTIBILITY:

All ages of lodgepole pine are susceptible.

SIGNS & SYMPTOMS:

Small, white blisters filled with orange spores develop from discoloured yellow patches on either side of the needles, in late spring or early summer. Alternate hosts are *Aster* spp.

DAMAGE:

Heavily infected older needles are cast. This disease can cause growth reduction in younger trees. In most cases, little or no damage will result from a light to moderate infection.

CAN BE CONFUSED WITH:

Heavily infected trees cast their older needles in the same fashion as the needle casts. However, western pine-aster rust-infected needles have the distinctive spore-filled blisters, and the infection tends to be more localized and on a lower percentage of needles per tree.

ELYTRODERMA NEEDLE CAST

Elytroderma deformans (Weir) Darker

Distribution

Throughout the range of ponderosa pine and lodgepole pine in BC, primarily the central interior and Kootenay areas.

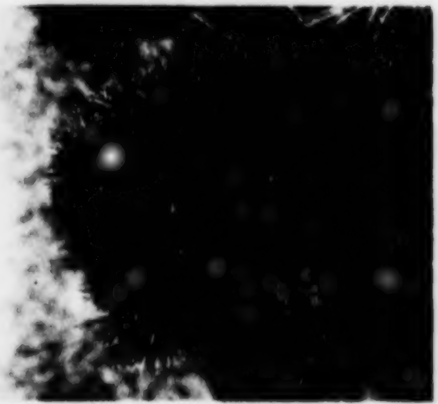


Fig 201. Upturned broom on ponderosa pine.

Fig 202. Lions' tails and dead foliage.

Fig 203. Discoloured needles and narrow, black fruiting bodies.

Host Susceptibility:

Ponderosa pine and lodgepole pine of all ages are susceptible.

Signs & Symptoms:

Needles infected the previous year do not show symptoms until spring of the following year, when needles initially turn bright red but fade to a straw colour. On lodgepole pine, occasional grey colouration occurs. Infected pine needles are cast in early fall for ponderosa pine and late fall for lodgepole pine. Thin crowns often result from needle casting, and lions' tails may be observed. On ponderosa pine, infection can produce small, open, and tufted brooms with upturned thickened twigs. Shoots supporting brooms have brown necrotic lesions in the inner bark. Needles discoloured from infection may display fruiting bodies in spring. Fruiting bodies begin as faint, narrow lines on the outer surface of infected needles, and blacken by late spring or early summer. Infection may be greater on moist sites such as valley bottoms or lake shores.

ELYTRODERMA NEEDLE CAST

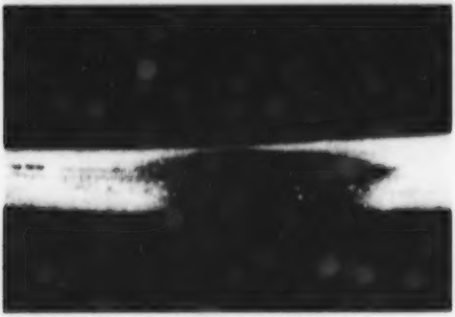


Fig 204. Ruptured needle with black, elongated fruiting structure.

DAMAGE:

This fungus is a unique needle cast fungus because it can spread from needles to shoot tissue. This results in broom formation and a perennial, systemic infection, allowing the fungus to survive periods of climate unfavourable for spore release. Light infection of less than 25% of the needles causes little damage. Severe infection will produce thin, ragged crowns and growth reduction. Tree or lower crown mortality can result from severe defoliation. Heavy infection can also predispose trees to attacks by other pathogenic fungi or insects. Younger trees are affected to a greater extent than older trees. Lodgepole pine up to 2 m in height can become systematically infected and remain stunted with needles in tufts at branch tips.

CAN BE CONFUSED WITH:

Pine needle casts such as *Lophodermella* may be confused with elytroderma needle cast. Look for the small dark streaks of the fruiting bodies on dead needles to confirm *Elytroderma.* Mistletoe brooms may occasionally be confused with *Elytroderma.* However, mistletoe broom needles are green and aerial shoots or basal cups are present.

RED BAND NEEDLE BLIGHT

Mycosphaerella pini (Rost. in Munk)

DISTRIBUTION

Throughout BC, following the range of its hosts.

Fig 205. Thin discoloured crowns.

Fig 206. Black elliptical fruiting bodies on ponderosa pine needles.

HOST SUSCEPTIBILITY:

All ages of lodgepole, ponderosa, and non-native pines are susceptible.

SIGNS & SYMPTOMS:

Infected needles display small, yellow-brown bands or spots. Needle tips distal to the bands or spots become reddish-brown shortly following infection, while the base of the needles generally remains green. Small, black fruiting bodies are revealed as the outer layer or epidermis of the needle is ruptured. Needle tissue adjacent to the black fruiting bodies are usually coloured brick red to red-brown (the colour fades on older dead needles). Older infected needles are usually shed in summer or fall, producing thin crowns in infected stands with a lion's tail appearance. Infections generally occur in the lower crown and on older needles. Needles of all ages may be infected, although infections are not uniform throughout the crown. Young trees are more commonly attacked than older trees. This disease is also commonly known as Dothistroma needle blight.

Fig 207. Necrotic needle tips.

Damages:

Exotic pine species planted in British Columbia have sustained heavy losses from this disease. Where environmental conditions favour infection, this disease can spread rapidly and cause significant damage. Trees can be defoliated within weeks, and mortality is common with repeated attacks, especially in young stands.

Can Be Confused With:

Lophodermella and elytroderma needle casts may be confused with red band needle blight from a distance. Closer inspection shows the distinctive dead tips and red-coloured tissue, with live bases on needles infected by red band needle blight.

PINE NEEDLE CAST

Lophodermella concolor (Dearn.) Darker

DISTRIBUTION

Throughout range of its hosts in BC, particularly the southern interior.

Fig 208. Lion's tail appearance of infected tree.

Fig 209. Discoloured needles with indistinct fruiting bodies, note black spot fruiting bodies are caused by Hendersonia pinicola.

HOST SUSCEPTIBILITY:

Lodgepole pine is the primary host. It is also reported on ponderosa and Scots pine. Trees of all ages are infected, but the most damage is to young stands.

SIGNS & SYMPTOMS:

Needles infected the previous year turn reddish-brown in May or June. In July, needles become straw-coloured. Concurrently-formed fruiting structures are the same colour as the surrounding needle surface and are difficult to see. The diseased needles on previous years' growth are shed as the summer progresses and remaining new growth has a lion's tail appearance.

DAMAGE:

This disease can cause severe defoliation. The years following periods of moist summer weather are favourable for infection. Growth reduction and mortality may result after repeated epidemics, particularly in young trees.

CAN BE CONFUSED WITH:

Elytroderma needle cast symptoms are similar; however, the long, black, fruiting structures are very different from the small, inconspicuous, lophodermella fruiting structures.

Other fungi often invade needles infected with *Lophodermella*, which may cause confusion regarding the fruiting structures. *Hendersonia pinicola*, itself not an important pathogen, fruiting structures appear as small black spots (seen in Fig 209).

DOUGLAS-FIR NEEDLE CAST

Rhabdocline pseudotsugae (Syd.)

DISTRIBUTION

Throughout the range of Douglas-fir.

Fig 210. Discolouration and defoliation.

Fig 211. Current needles do not show symptoms of infection.

Fig 212. Ruptured needle epidermis exposing brown, elongated fruiting body.

HOST SUSCEPTIBILITY:

Douglas-firs from seedlings up to trees 30 years of age are susceptible. Older trees can be attacked but damage is usually minimal.

SIGNS & SYMPTOMS:

The first symptom is pale yellow spots on needles, most commonly near the tips, in the fall or early winter. By the following spring these spots change to reddish-brown and are in sharp contrast to the rest of the needles, which remain green. At this stage, infected needles appear mottled and during severe infestations trees appear scorched. Fruiting structures of Douglas-fir needle cast develop in May or June, usually on the lower surface of the needle. The fruiting structures are small swellings at first. Later, the needle epidermis ruptures in an irregular longitudinal split to expose the brownish fruiting structure. Infected needles are shed soon after the appearance of fruiting bodies. Current years' needles do not show infection until the fall. This disease is most prevalent during periods of moist climatic conditions. Dense, pure stands are most susceptible to infection, although tree suppression is apparently not a factor.

Fig 213. Red discolouration of needles due to infection of previous year.

Damage:

Repeated heavy infections can completely defoliate trees, with the exception of current needles. In some cases, mortality or substantial growth reduction result, especially on small trees. This is less severe in coastal stands. Christmas-tree plantations can be severely damaged.

Can Be Confused With:

Needle mottling from this disease may be distinguished from that caused by the cooley spruce gall adelgid, because these insects produce smaller patches of chlorosis throughout the growing season. Also, needles attacked by cooley spruce gall adelgid are often distorted, and signs of the insect are usually present. Swiss needle (*Phaeocryptopus gaeumannii*) cast also causes similar damage, but the fruiting bodies are very small, round, and black. It is not an important damage agent in the province.

FIR-FIREWEED RUST

Pucciniastrum epilobii (Otth.)

DISTRIBUTION

Throughout the range of its hosts in BC.

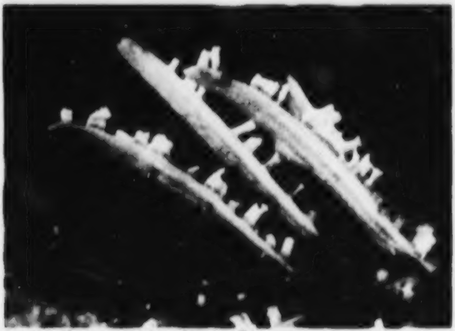


Fig 214. Blisters containing white or yellow spores.

HOST SUSCEPTIBILITY:

Amabilis fir, white fir, and sub-alpine fir of all ages are susceptible, though it is most serious in young stands. Fireweed is an alternate host.

SIGNS & SYMPTOMS:

Small blisters filled with white or yellow spores develop on the lower side of current-year needles in late spring to early summer. The infected needles become chlorotic or discoloured and may be shed prematurely.

DAMAGE:

Severe infection can almost completely defoliate current-year needles. Growth reduction may result. Mortality has occurred in young stands growing in recently logged areas where fireweed is abundant.

Fig 215. Current growth killed due to infection.

CAN BE CONFUSED WITH:

Several other needle rusts are found on true firs, and could be confused with fir-fireweed rust. Examination of the spores and the location of the damage will differentiate these rusts.

DELPHINELLA NEEDLE CAST

Delphinella spp.

DISTRIBUTION

Throughout the range of sub-alpine fir in BC.

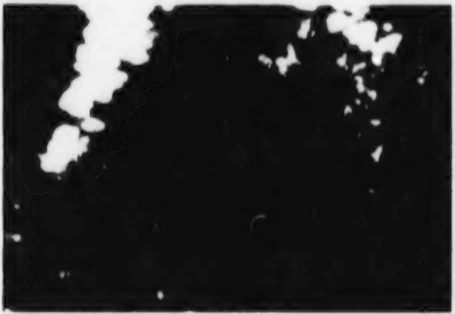


Fig 216. Slightly chlorotic new growth.

HOST SUSCEPTIBILITY:

Sub-alpine fir of all ages are susceptible.

SIGNS & SYMPTOMS:

Needles on new shoots appear slightly chlorotic early in the spring. Cankers at the base of infected needles then girdle and kill the needles. As the fungus moves into the shoots, the shoots begin to wilt and shrivel. Infections that start early in the spring tend to kill all or most of a shoot and its needles. Infections later in the season may only kill some needles and just the tip of an infected shoot. Dead needles and shoots remain attached for one to several years, and turn red or brown the first year, and grey or black the second year. Spores are not produced on the needles until the following spring. The fruiting bodies are very small, round, and black, and develop on the upper surface of needles and on the shoots.

DAMAGE:

New shoots and needles are killed soon after they develop in the spring or early summer. Severe infection can halt branch and terminal growth for a year, and chronic infection can stunt tree growth.

CAN BE CONFUSED WITH:

Frost damage is very similar in appearance. The absence of damage on nearby frost-susceptible trees of other species and the presence of fruiting bodies distinguish delphinella needle cast.

LARCH NEEDLE CAST

Meria laricis (Vuill.)

DISTRIBUTION

Throughout the range of its hosts, primarily southeastern BC.

Fig 217. Uninfected needles remain attached after infected needles are shed on young larch.

HOST SUSCEPTIBILITY:

All ages of western larch are susceptible.

SIGNS & SYMPTOMS:

Needles of the lower crown are most heavily attacked. The middle or tip of a needle is initially infected. This area turns yellow, wilts, and becomes reddish-brown soon after. The infection and accompanying discolouration eventually cover the entire needle. Most needles are shed in the same year they die, but needle casting may continue throughout the growing season. Larch needle cast and larch needle blight commonly occur together, even on the same needles.

DAMAGE:

A single heavy defoliation will cause only minor growth reduction in larger trees; however, young trees may be killed. Significant mortality has occurred in forest nurseries. Infections predispose trees to damage by other agents, such as root diseases or abiotic disorders.

CAN BE CONFUSED WITH:

Initially may be confused with frost damage, but frost damage tends to kill both needles and young stems, and tends to be heaviest in the upper crowns of trees. Larch casebearer defoliation appears superficially like needle blight, but the insect attacked needles are hollow, shriveled, and kinked. Several rust fungi are also found on larch. These can be distinguished by their spore-producing, fruiting structures. Larch needle blight is also similar, except blight infections occur only in the spring, black fruiting bodies are visible, and most infected needles are retained after healthy foliage is shed in the autumn.

Fig 218. Discolouration of needles. Initial infection is near middle or tip and fruiting bodies are not visible.

LARCH NEEDLE BLIGHT

Hypodermella laricis (Tub.)

Distribution

Primarily southeastern BC.

Fig 219. Wilted reddish-brown needles symptomatic of infection.

Fig 220. Necrotic needles. Note black fruiting bodies.

Host Susceptibility:

All ages of western larch are susceptible.

Signs & Symptoms:

Infection commences in spring on newly flushed foliage, causing needle droop and premature colour change from green to reddish-brown. A severely infected stand develops a scorched appearance. The entire crown may be affected on small trees; infections in older trees are usually more prominent in the lower crown. Infected needles remain attached to the spur shoots for up to two years after healthy foliage is shed in the fall. Fruiting bodies appear as small, elliptical black spots. This disease may occur concurrently with larch needle cast, even on the same needles.

Damage:

This disease infects only needles; however, spur shoots may die after successive severe defoliations. Tree mortality is possible in young trees. Repeated infections of the same tree are uncommon. Western larch usually produces new foliage in the spring following an infection. Therefore, damage is usually limited to minor growth reduction.

Fig 221. Stand of affected western larch turning reddish-brown.

CAN BE CONFUSED WITH:

May be confused with frost damage, but frost damage tends to kill both needles and young stems, and no fruiting bodies are found. Feeding by budworms appears similar, but closer inspection reveals signs of chewing, frass, and webbing. Larch casebearer defoliation appears superficially like needle cast, but attacked needles are hollow, shriveled, and kinked. May also be confused with larch needle cast, but blight-infected needles have small black spots and are retained after normal leaf drop.

BROOM RUSTS

Broom rusts cause conspicuous clusters of infected branches on their coniferous hosts. These fungi require an alternate host for completion of their life cycle, but persist as a systemic infection in brooms. On the broom branches, new needles are infected each year, resulting in conspicuous yellowish to orange witches' brooms. The discolouration is due to dying and dead foliage and the presence of fungal spore masses on the needles. In the summer or autumn, infected needles are shed, leaving bare branches. Dead branches, stem deformity, and growth reduction result from infection. Tree mortality is not common.

FIR BROOM RUST

Melampsorella caryophyllacearum (Schroet.)

DISTRIBUTION

Throughout the host range in BC.

HOST SUSCEPTIBILITY:

Amabilis fir, grand fir, and sub-alpine fir are the major hosts. An alternate host is chickweed.

Fig 222. Discoloured upright broom.

SIGNS & SYMPTOMS:

Distinctive, greenish-yellow, upright brooms are visible in summer. The colour of these brooms contrasts with the strong green of healthy needles on the same tree. Broom needles are pale yellow, shorter and thicker than normal needles, and are arranged in a spiral. In summer, the underside of these needles are covered with blisters filled with yellow or orange spores. The broom needles are cast in the fall and a new flush appears in the spring. At the base of the broom, infected branches and stems are swollen, forming a canker or a gall.

DAMAGE:

In British Columbia damage has been light; however, volume loss, growth reduction, and mortality can occur as a result of this disease. Volume loss results from trunk swellings, cankers, and spike-tops. Growth reduction results from decreased productive crowns, and direct mortality may result from excessive numbers of brooms. Indirect mortality may result from attacks by secondary insects or wind breakage at or near a broom.

Fig 223. Typical short, yellow, infected needles found on brooms.

CAN BE CONFUSED WITH:

The brooms and swellings caused by fir broom rust could be confused with mistletoe infections or genetic abnormalities. However, the chlorotic needles in the summer and complete loss of needles in the winter identify fir broom rust. True firs are seldom infected by dwarf mistletoes, and needles on a dwarf mistletoe broom remain green.

SPRUCE BROOM RUST

Chrysomyxa arctostaphyli (Dietel)

DISTRIBUTION

Throughout the range of spruce in BC.

Fig 224. Needles infected showing small spore laden blisters.

HOST SUSCEPTIBILITY:

All native spruce species are susceptible. An alternate host is kinnikinnick.

SIGNS & SYMPTOMS:

Conspicuous orange-yellow brooms are apparent in the summer months. The discoloured needles are shed in fall and new pale green needles are produced the following spring. Closer examination of broom needles in mid-summer reveal small, orange-yellow blisters filled with spores. Brooms caused by this disease grow perennially and may be greater than 30 years old and up to 2 m in diameter.

DAMAGE:

Tree form can be affected by this disease, including the production of spike-tops, dead branches, and stem deformation. This disease may also cause growth reduction and predispose trees to decay fungi and windbreakage. Mortality is sometimes associated with this disease.

Fig 225. Older orange-yellow broom. Deformity and growth reduction are common.

CAN BE CONFUSED WITH:

The brooming symptoms caused by the spruce broom rust could be confused with those caused by other agents. However, distinguishing features of the rust are the yellow-orange colour of the broom needles in the summer, and the shedding of the needles in the fall.

Introduction to Abiotic Damage of Coniferous Trees

Injuries caused by non-living agents are termed abiotic disorders. Abiotic tree damage or disorders in British Columbia include frost, ice/snow/hail, red belt/winter kill, drought, sunscald, cedar flagging, and road salt. Nutrient deficiencies are also an abiotic damage agent, but are not described in this guide. Local topography can favour certain conditions, such as frost damage. Decreased wood quality and volume may result. In addition, trees stressed by abiotic damage are often predisposed to disease and insect attack.

Symptoms caused by abiotic factors are usually very similar to those caused by other agents. Generally, non-infectious abiotic damage can be found on a wide variety of plant species, while symptoms and signs of infectious diseases are found only on specific hosts. Before suspecting that abiotic disorders are present, always check affected areas for evidence of disease, or animal or insect activity or feeding. This may include cankers, fruiting bodies, specific root disease or decay characteristics, insects, webbing, girdling, or animal tracks. In addition, consider local climate records, topography, roads, potential for cold air ponding, and other disturbances when determining which abiotic factor caused damage.

DISTRIBUTION

Throughout BC, particularly in areas of poor air drainage (frost pockets) or cold wet soils.

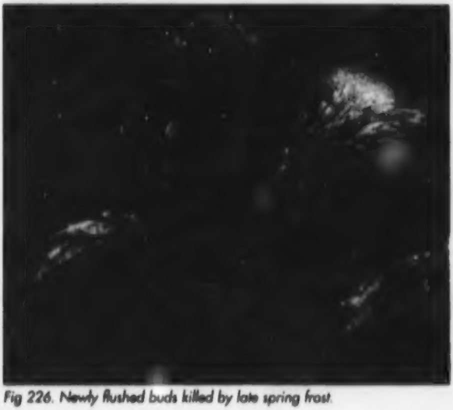


Fig 226. Newly flushed buds killed by late spring frost.

TREE SPECIES AFFECTED:

All trees of all ages are susceptible. Interior varieties are more tolerant than coastal varieties of the same species. Douglas-fir is most commonly affected in central BC.

SIGNS & SYMPTOMS:

Frost injury results when unusually cold temperatures freeze sensitive new growth or older tissues not yet sufficiently hardened off for winter. Late spring frost affects buds just breaking dormancy and succulent new growth. Injury is visible within two days of frost incidence when foliage becomes limp and fades to yellow. After approximately one week, killed buds turn dark brown and soft. Affected foliage of the branch tips becomes red-brown and droopy. These symptoms are often most pronounced in the upper crown of smaller trees on the emerging succulent foliage.

Frost lesions are rough, callused patches on the main stem created by frost-killed cambium. Necrotic bark eventually sloughs off to expose the sapwood.

Fig 227. Frost crack extending up main stem.

Raised lateral woody folds, called frost ribs, surround older cankers. This type of injury generally occurs on young to pole-sized trees. Subsequent freezing of these lesions can cause internal radial shake, seen as brownish, resin-soaked rings of disrupted wood.

Frost cracks are usually seen in older trees, especially with true fir species. This type of damage is characterized by long, dark vertical cracks in the main stem. Frost heaving is almost exclusively restricted to first-year seedlings in cold, poorly drained soils. Affected seedlings are ejected from the soil and their roots are generally broken within several centimetres of the root collar.

Fig 228. Wilted necrotic needles resulting from late spring frost damage to recently flushed foliage.

Damage:

Late spring frosts are usually more injurious than early fall frosts. Reduced lateral and leader growth or tip dieback are common. Frost heaving is also caused by late spring frosts, and can result in significant seedling mortality on newly planted sites at higher elevations. Internal radial shake can adversely affect growth rates and wood quality. Frost lesions or frost cracks act as entry points for canker and decay fungi or can lead to stem breakage. Several canker fungi act as weak pathogens following frost damage, and cause substantial dieback and branch flagging injury.

Fig 229. Seedling mortality caused by frost.

Similar Damage:

A variety of biotic and abiotic agents can cause damage resembling frost damage. Repeated frost injury resembles damage caused by animal browsing. Consider climatic conditions, and look for signs of animal activities to distinguish between these agents. Frost cracks may be confused with lightning hits. However, lightning injury leaves a more jagged furrow in the bark, and may have an accompanying broken top. Shoot damage by insects such as the terminal weevil can be similar to late spring frost damage. Look for signs of insect feeding and activity to identify the causal agent.

Fig 230. Frost-injured tips initially turn yellow. Older damage is dark brown.

DISTRIBUTION

Throughout BC wherever the incidence of snow, ice, or hail is significant.

Fig 231. Hail-caused lesions on upper surface of branch.

TREE SPECIES AFFECTED:

All conifers are susceptible. Douglas-fir is more readily damaged than true fir, pine, or hemlock species.

SIGNS & SYMPTOMS:

Snow damage consists of temporarily or permanently bent main stems, depending upon duration and movement of the snow pack, and branch stripping or breakage, stem breakage, or uprooting. Symptoms are concentrated in small groups or are seen on scattered individual trees in affected stands. Older trees can suffer top breakage. Windblown ice crystals abrade portions of the main stem above the snowline. Affected areas of the stem have a smooth appearance. Hail damage symptoms can be seen over a broader area and consist of stripped branches, stem lesions, scars and bruises on the upper surface of branches, or tattered, ragged crowns with missing foliage and buds. Damage symptoms are aligned in one direction. Buds, foliage, and branches litter the ground. Larger seedlings and saplings show more symptoms than smaller trees.

DAMAGE:

Heavy snowfall or hail can cause significant mortality in young plantations. Losses occur in patches or as scattered individual trees. Growth is reduced when foliage and buds are removed. In younger trees, deformity results from permanently bent main stems or broken tops due to snow press. Deformity of older trees is caused by top breakage. Hail-related branch or stem scars and top breakage act as entry points for disease.

Fig 232. Broken and bent stems caused by heavy snow pack.

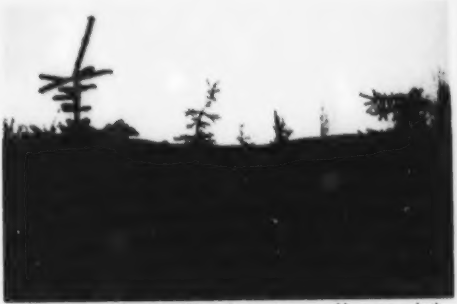


Fig 233. Crown deformity and branch stripping caused by snow or hail.

SIMILAR DAMAGE:

Broken or uprooted trees can be symptomatic of stem weakening diseases such as rusts, heartrots, or root rots. These may occur in conjunction with snow press. Investigate the stems and roots for signs of diseases. Old hail damage can be confused with other agents such as old insect feeding. However, hail damage always occurs on only one side of the tree, while damage from other causes usually occurs on all sides of the tree.

DISTRIBUTION

Throughout BC, mainly along the middle to upper portions of south to southwest slopes, and occasionally in valley bottoms.

Fig 234. Typical bands of reddish-brown trees caused by red belt.

TREE SPECIES AFFECTED:

All conifer species of all ages are susceptible, particularly lodgepole pine.

SIGNS & SYMPTOMS:

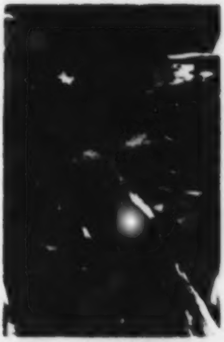


Fig 235. Leader exhibiting winter kill symptoms.

Symptoms usually appear in spring as reddish-brown discolouration of foliage, which when viewed from a distance, appears as a well-defined horizontal band across a slope. Red belt is the result of a combination of climatic conditions. The unseasonable occurrence of warm, dry winds by day, followed by cold air drainage at night, leads to dessication injury. Frozen soils do not allow lost moisture to be replaced quickly enough, and affected needles discolour and are eventually shed. Symptoms are often more pronounced in the upper crown and on the sides of trees facing the prevailing wind. Unopened buds are usually not harmed.

Winter kill is a similar phenomenon that occurs on flat terrain. Symptoms on individual trees are most obvious above an often abrupt line that matches the snow level at the time of injury.

DAMAGE:

Foliage and occasionally open buds are killed. Trees often recover from extensive defoliation but mortality may result from repeated red belt damage or destruction of all buds. Affected trees have a reduction in growth rate. Trees weakened by red belt are more susceptible to insect attack or disease. Large areas of red belt increase the fire hazard for the summer following the event.

SIMILAR DAMAGE:

May be confused with other abiotic disorders such as drought. A distinguishing feature of red belt when it occurs on slopes is the distinct elevational banding. Consider the climatic conditions preceding the damage, and the time of year that it becomes noticeable.

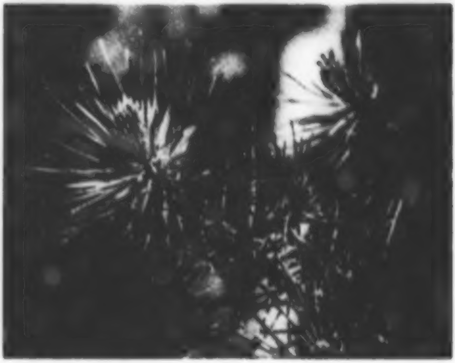


Fig 236. Affected foliage is discoloured but remains undistorted.

DISTRIBUTION

Throughout BC in areas experiencing unusually low rainfall, especially on sites with dry aspects and shallow, well-drained soils or areas where excessive soil disturbance has occurred.

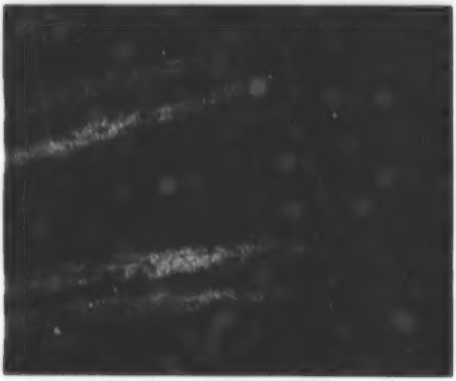


Fig 237. Detail of drought stress symptoms on needles.

TREE SPECIES AFFECTED:

All conifer species are susceptible, especially seedlings or young saplings. Species or varieties adapted to dry sites are more tolerant than those adapted to moist sites. Understory or shallow-rooted trees are usually more severely affected.

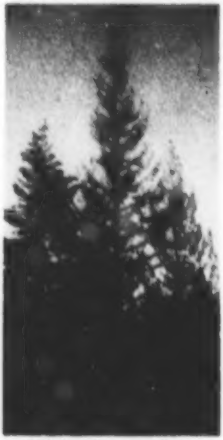


Fig 238. Symptoms move from crown top down and from branch tips inward.

SIGNS & SYMPTOMS:

Drought symptoms are most apparent in late summer to early fall and can occur over extensive areas. Trees growing on shallow, gravelly, or sandy soils will show symptoms early in drought conditions. Younger trees become affected earlier than older trees, since the former have a smaller root system. Trees undergoing only moderate moisture stress will shed older needles prematurely, usually on the lower crown. Seedlings show wilting, yellowing, and necrosis of the foliage. Older trees exhibit symptoms from the top down and from the outside inward. Affected foliage eventually discolours brown in all species except larch. On larch, foliage turns yellow, droops, or shrivels around the stem or branches, and falls off abnormally early. With well-advanced drought conditions, foliage discolouration and needle death become more pronounced and tip dieback may be seen. On western white pine, drought-related stem cracks are sometimes found.

Fig 239. Foliage discolouration and necrosis caused by drought.

Damage:

Drought can cause extensive mortality for four or five years after planting. The growth of surviving trees is often retarded. Damage is a result of growth reduction, dead tops, and defoliation. However, if drought occurs over several successive years, large trees of drought-intolerant species may die. A widespread decline of western white pine from 1950 to 1960 ("poleblight") resulted from drought.

Similar Damage:

Many conditions that affect individual tree health can resemble drought damage. Root disease, needle cast, and insect defoliation can be distinguished by fruiting bodies and insect feeding respectively. Other abiotic disorders, such as frost and red belt, can be distinguished by climatic or topographic conditions preceding or associated with the damage.

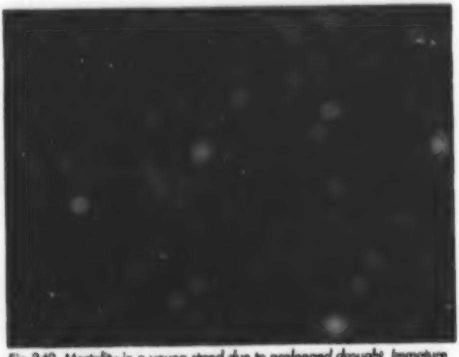


Fig 240. Mortality in a young stand due to prolonged drought. Immature trees are generally more susceptible to damage.

SUNSCALD

DISTRIBUTION

Throughout BC wherever temperatures from insolation reach levels high enough to kill the cambium in young trees.

Fig 241. Coppery red bark of an immature Douglas-fir affected by sunscald.

TREE SPECIES AFFECTED:

Young trees of any species are susceptible, particularly Douglas-fir.

SIGNS & SYMPTOMS:

The southwest side of the main stem of young trees is generally most affected. The outer bark on the stems of recently damaged trees is coppery to bright red. Older damage is a darker red to brown colour. This discolouration fades by the end of summer. Dead bark shrinks, becomes loose, and sloughs off. Sunscald cankers may vary from small patches to large areas extending almost the entire length of the exposed stem. Injured areas are confined to smooth, unfissured sections of the bark. Damaged trees are commonly seen in summer on droughty sites or in areas where thinning or pruning has been carried out, since these conditions expose shade-

Fig 242. Necrotic lesion caused by sunscald.

grown trees to the effects of intense direct sunlight. Rapidly growing trees may also be affected. Sunscald incidence is often greater along the open or southern-exposure edges of a stand.

Fig 243. Sunscald-killed Douglas-fir. Damage may be more frequent along perimeter of dry, exposed sites.

Damage:

Areas of dead bark may allow the entry of decay-causing fungi. Significant growth loss or mortality is seldom directly attributable to sunscald. Damaged trees may be more susceptible to root diseases like armillaria and black stain.

Similar Damage:

Dermea and phomopsis cankers may be confused with sunscald damage. However, no fruiting bodies are present, and sunscald damage is generally confined to the southwest side of the stem.

DISTRIBUTION

Throughout the range of western redcedar.

Fig 244. Dead foliage on branchlets of western redcedar.

TREE SPECIES AFFECTED:

All ages of western redcedar are susceptible.

SIGNS & SYMPTOMS:

Isolated branchlets of old foliage scattered over the whole tree have yellow to red, dying or dead foliage. Flagging is a normal condition of western redcedar and is most evident after hot dry summer weather. All of the flagging occurs in the same time period.

DAMAGE:

Entire branchlets die, but cedar flagging does not have a detrimental effect on tree growth.

SIMILAR DAMAGE:

Cedar flagging symptoms bear superficial resemblance to cedar leaf blight when the latter occurs in the fall. However, small, black, leaf-blight cavities will not be found in the upper surface of leaves exhibiting cedar flagging.

ROAD SALT

DISTRIBUTION

Throughout BC, on roadside trees in areas of significant snowfall or icy conditions, where salt is applied to the roads.

Fig 245. Trees showing road salt damage.

TREE SPECIES AFFECTED:

All species of all ages are susceptible. Douglas-fir is commonly affected, lodgepole pine and spruce less commonly.

SIGNS & SYMPTOMS:

Salt causes damage to conifers by splash that lands on the needles of trees directly beside a road, and to both conifers and hardwoods through buildup in the soil at the point where salt-laden water tends to accumulate. Salt water accumulation is usually on the downhill side of a road, and symptoms can be present a significant distance from the road if the slope is steep and unbroken. Run-off water in spring can flow for considerable distances on frozen soil, even on gentle slopes. Conifers usually show the most damage on the side of the tree facing the road, and on the distal half of the needles when splash is the cause. Trees near septic tank drainage fields often are similarly affected by salt used for conditioning domestic water.

Damage is most apparent in the spring. By summer, injured foliage is often shed, and new foliage disguises the damage.

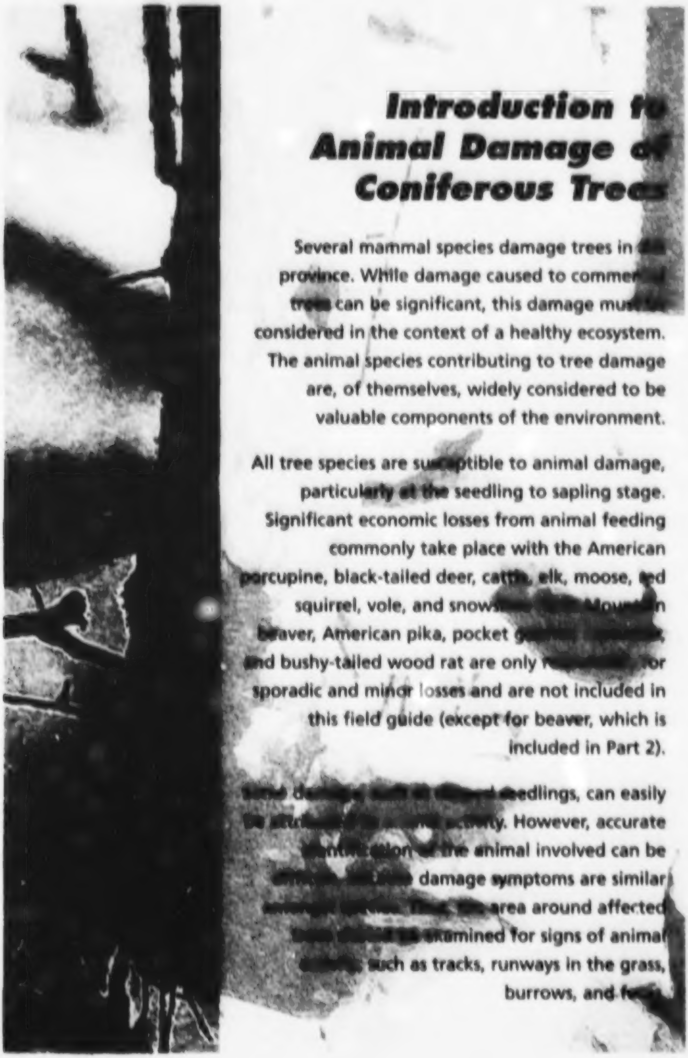
ROAD SALT

DAMAGE:

Damage from salt accumulation in the soil can kill some conifers, particularly Douglas-fir, and can cause significant twig dieback on hardwoods. Leaves of damaged hardwoods often show browning on the margins.

SIMILAR DAMAGE:

Salt damage may be confused with other abiotic disorders. Consider the proximity of the damaged trees to a road where salt has been applied.



Introduction to Animal Damage of Coniferous Trees

Several mammal species damage trees in this province. While damage caused to commercial trees can be significant, this damage must be considered in the context of a healthy ecosystem. The animal species contributing to tree damage are, of themselves, widely considered to be valuable components of the environment.

All tree species are susceptible to animal damage, particularly at the seedling to sapling stage. Significant economic losses from animal feeding commonly take place with the American porcupine, black-tailed deer, cattle, elk, moose, red squirrel, vole, and snows[illegible] Mountain beaver, American pika, pocket g[illegible], and bushy-tailed wood rat are only r[illegible] for sporadic and minor losses and are not included in this field guide (except for beaver, which is included in Part 2).

[illegible] seedlings, can easily be [illegible] activity. However, accurate identification [illegible] the animal involved can be [illegible] damage symptoms are similar [illegible] area around affected [illegible] examined for signs of animal [illegible] such as tracks, runways in the grass, burrows, and fe[illegible]

DEER / ELK / MOOSE

Odocoileus spp. / *Cervus* spp. / *Alces alces* (Clinton)

DISTRIBUTION

Throughout BC.

TREE SPECIES ATTACKED:

All tree species are susceptible. Western redcedar is particularly susceptible to browsing by black-tailed deer and elk on the coast, especially for deer on islands that lack predators, such as the Queen Charlottes and Texada. Elk and deer damage also occurs in the interior, but is not as serious as browse damage on the coast. Moose browsing is most common in the interior. Nursery stocks have high nutrient content and are particularly sought after.

SIGNS & SYMPTOMS:

Terminal and lateral shoots are removed from seedlings and saplings during browsing activities. Browsed ends are squarely cut and have a ragged appearance. Feeding deer sometimes uproot seedlings entirely. Young bark may be peeled from sapling stems, leaving vertical toothmarks approximately 4 to 6 mm wide in the exposed sapwood. Bark is also stripped from the branches and trunk of saplings during antler polishing in the fall. Shredded bark clings to these injured areas. All the preceding injuries are confined to the lower 1.5 m of the tree for deer browse, higher for elk, and up to 2.3 m for moose. Stunted, bushy growth is seen on seedlings and saplings that have been repeatedly browsed. The distribution of browsed trees in a plantation is often clumped. Droppings are usually found. Numerous trails can be seen when the ungulate population is high in the local area.

Fig 246. Stunted, bushy growth of Sitka spruce resulting from repeated browsing.

DAMAGE:

Occasionally, seedlings are killed when pulled from the ground. More commonly, browsing on terminal and lateral shoots causes growth loss and deformation in seedlings and saplings. Repeated browsing results in severe height suppression over extensive portions of affected plantations. Most damage occurs in the spring during bud flush. Elk are herding animals, and may trample trees.

SIMILAR DAMAGE:

Distinguishing between the different browsing ungulates is difficult. The height of the browsing can be a clue; for example, large moose may browse as high as 2.3 m, while deer browse below 1.5 m. Local population knowledge, dropping size, and track size will also help distinguish the animal.

Fig 247. Peeling of bark from seedling by the upward scraping of incisors.

Fig 248. Deer browsing of Douglas-fir seedling.

RED SQUIRREL

Tamiasciurus hudsonicus (Erxleben)

DISTRIBUTION

Throughout BC, except for the Queen Charlotte Islands and the south coast mainland. Attacks are concentrated in the central southern interior.

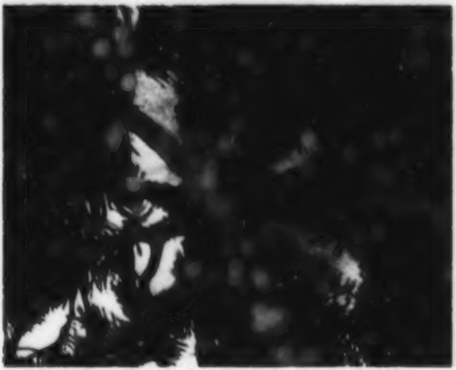


Fig 249. Girdling of branches by red squirrel. Chewed surface of sapwood is smooth.

TREE SPECIES ATTACKED:

Damage is primarily on young lodgepole pines (between 6 to 20 cm dbh), but may also occur on western larch, ponderosa pine, western white pine, Douglas-fir, grand fir, and birch.

SIGNS & SYMPTOMS:

Red squirrels cut or peel the lateral and terminal shoots, and remove or hollow out the buds. These are often found on the ground around affected trees. Vertical or diagonal strips of bark up to 1 cm wide are gnawed from the branches and main stem of saplings. Gnawed surfaces are relatively smooth and toothmarks are indistinct. Squirrels often feed on pine stem rust blisters and mistletoe infections. Short strips of bark may be found at the tree base as a result of crown girdling, and occasional dead tops may be visible. Most damage occurs in spring and early summer. Freshly cut cones and piles of cone scales on the ground indicate squirrel activity. Droppings are 8 mm in length, elliptical, and are found on logs and stumps where squirrels have been feeding.

Fig 250. Squirrels often gnaw patches of bark.

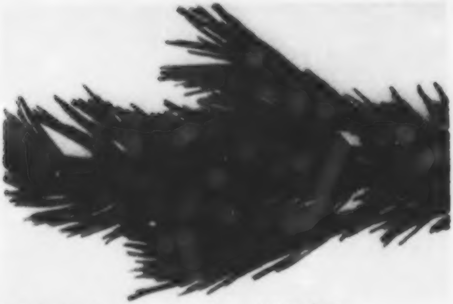


Fig 251. Discoloured branch tips damaged during feeding.

DAMAGE:

Tree growth is reduced due to feeding on the lateral or terminal buds. Scattered dead tops result from occasional girdling in the crown. Partial basal girdling of saplings can occur over extensive areas in some plantations, leading to reduced growth and scattered mortality. Squirrel populations fluctuate with the size of the spruce and Douglas-fir cone crop. Thus, damage may be more noticeable during some years than others.

SIMILAR DAMAGE:

Crown girdling in larger trees may be confused with porcupine damage. Short strips of bark at the base of the tree can help to distinguish recent squirrel damage. Hare damage to sapwood is similar to squirrel damage; however, the gnawed appearance of the sapwood and the size of the trees attacked distinguished hare damage from squirrel damage.

Fig 252. Damage to lateral shoots from activity in upper crown.

SNOWSHOE HARE / COTTONTAIL RABBIT

Lepus americanus (Erxleben) / *Sylvilagus* spp.

Distribution

The snowshoe hare is found throughout BC, except in the north coastal area and coastal islands. The cottontail rabbit is distributed in the south-central portion of BC.

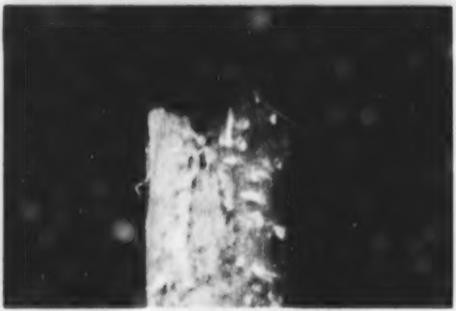


Fig 253. Ragged, exposed sapwood caused by hare feeding.

Tree Species Attacked:

Hare damage has only been reported from the north and central interior. All conifer tree species are susceptible, particularly lodgepole pine. Only trees with a diameter less than 6 cm are susceptible.

Signs & Symptoms:

Fig 254. Seedling leader clipped by a hare.

Snowshoe hare and cottontail rabbit cause similar injuries, primarily in the winter. However, damage from cottontail rabbit is much less common. Seedlings are cut in an oblique, knife-like manner and the lateral or terminal shoots are removed. Bark is gnawed in small patches near the base of the stem or on the lower branches. Feeding damage may occur higher on the tree, depending on snow depth. The stem is occasionally girdled. Exposed sapwood exhibits a shaggy or ragged appearance with indistinct horizontal or diagonal toothmarks about 2 mm in width. High-risk stands occur in areas between clearcuts with young seedlings, and high-density, second growth, pole-size pine stands with a dense brushy understory. Newly planted seedlings or trees that have recently been fertilized are most attractive. Droppings are slightly flattened and circular, about 1 cm in diameter, and are often found in small clusters. Cottontail rabbit droppings are more disk-shaped, while those of the snowshoe hare are pellet-like. Tracks made by the hind feet of these species are elongate, but the snowshoe hare leaves longer imprints.

DAMAGE:

Smaller seedlings are highly susceptible to mortality from clipping at the root collar. Larger seedlings suffer deformity, reduced growth rate, and occasional mortality. Young lodgepole pine not covered by snow are very susceptible to damage. Most damage occurs within several years of planting and follows a very regular 9 to 11-year population cycle.

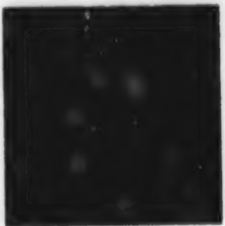


Fig 255. Mortality due to stem girdling.

SIMILAR DAMAGE:

Feeding by voles on seedlings may be confused with hare or rabbit damage. Look for differences in toothmarks when feeding is on the stem, and for animal signs, such as droppings. For vole damage, exposed sapwood appears fuzzy, while for hare damage, it is ragged. Vole damage is typically on seedlings or at the base of small trees, as voles feed under the snow.

Hares typically feed on the bole of young trees less than 6 cm dbh, and on top of the snow. Squirrel damage is usually on the bole of young trees over 6 cm dbh. Although squirrel damage is similar to that of hares and rabbits, the teethmarks are different, and the exposed sapwood is smooth.

VOLES

Microtus spp.

Distribution

Throughout BC, except for the Queen Charlotte Islands.

Fig 256. Plantation damage resulting from extensive vole activity.

Tree Species Attacked:

Commonly damaged tree species include Douglas-fir, western hemlock, lodgepole pine, spruce, western redcedar, grand fir, and cottonwood. Voles commonly feed on seedlings and less commonly, saplings.

Signs & Symptoms:

Fig 257. Clipping of terminal and lateral shoots of lodgepole pine seedling by voles.

Voles clip the terminal and lateral shoots of small seedlings, leaving a rough, oblique cut. Larger seedlings and saplings are debarked and often girdled. The bark is gnawed rather than stripped, giving the exposed sapwood a fuzzy appearance. Toothmarks are indistinct, averaging 1.5 mm wide and 8 mm long, and resemble light scratches. Irregular patches of gnawed bark can also be seen on the roots, root collar, lower stem, and occasionally on the lower branches. Small runways can be found in the grass and small piles of clipped vegetation occur along these paths. Small tunnels can occur in soft soil. Vole droppings are cylindrical, have round ends, and are about 5 mm long.

Locations where voles are a problem are clearcuts with lush, grassy-brushy vegetation, near a water source.

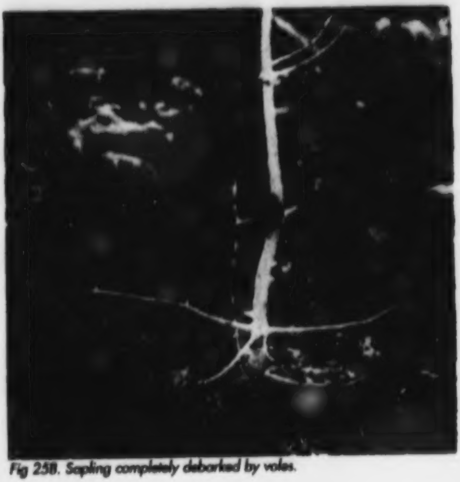


Fig 258. Sapling completely debarked by voles.

Damage:

Most damage occurs during very high population densities over the winter and can be extensive in some plantations. Winter feeding usually takes place under the snow in the interior. Small seedlings have reduced growth or are killed as a result of clipping. Growth rates of larger seedlings and saplings can also be adversely affected by feeding activities on the roots, root collar, lower stem, and lower branches. Girdling of these trees causes scattered mortality.

Fig 259. Surface runway of voles.

Similar Damage:

The brown lemming can cause similar damage in the northwest portion of the province. The oblique cutting of shoots is similar to hare damage, but vole cuts are rougher due to the several cuts required to sever the stem.

CATTLE

Bos taurus (Linnaeus)

DISTRIBUTION

Throughout BC, with the most heavy grazing in the Cariboo and Kamloops forest regions.

Fig 260. Damage to lodgepole pine by cattle rubbing.

TREE SPECIES ATTACKED:

All tree species can be damaged. Lodgepole pine, ponderosa pine, and Douglas-fir are particularly susceptible. Seedlings and small saplings are the most affected, though all sizes are at risk.

SIGNS & SYMPTOMS:

Browsing, trampling, pulling, and rubbing are all physical injuries that may be caused by cattle. Damage is more likely and more severe if the livestock are confined to a small area, or if they do not have access to abundant and palatable forage. The tender new growth of ponderosa and lodgepole pine may be browsed even when sufficient fodder is available.

DAMAGE:

Browsing can cause growth loss and deformation in seedlings and saplings. Seedlings can be uprooted. Trampling is the most common damage to young seedlings, which can result in severe injury and high mortality in overgrazed areas. Larger trees can be injured by rubbing or scraping, which can result in bark removal and stem disfigurement. Placement of salt licks, location of water sources, herd management and some site preparation techniques can all contribute to cattle damage.

Similar Damages

Wild ungulates may occupy plantations at the same time as cattle, and can cause similar damage that is difficult to distinguish. Tracks, fecal pies, and several site visits may be required to tell the difference between cattle damage and other large mammal damage.

Fig 261. Damage to lodgepole pine by cattle rubbing.

AMERICAN PORCUPINE

Erethizon dorsatum (Allen)

DISTRIBUTION

Throughout BC, except for Vancouver Island and the Queen Charlotte Islands.

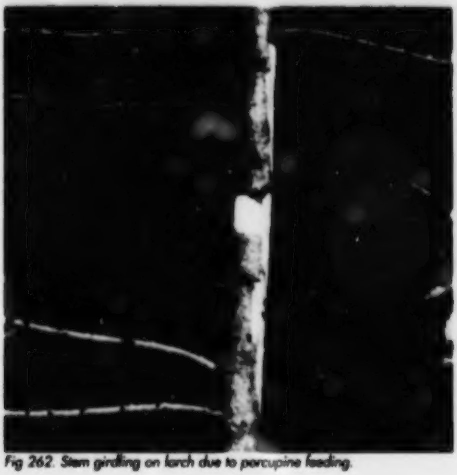


Fig 262. Stem girdling on larch due to porcupine feeding.

TREE SPECIES ATTACKED:

Sitka spruce, ponderosa pine, Douglas-fir, and western hemlock are attacked, with sapling-sized and larger trees being particularly susceptible. All other conifer species, of all ages, are affected less frequently.

SIGNS & SYMPTOMS:

Porcupines damage trees during the winter when they feed on the inner bark. They discriminate by taste and will select individual trees for feeding, while leaving other nearby trees undamaged except for a small test feeding patch.

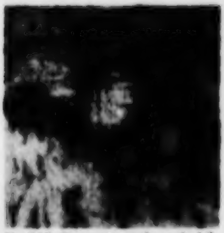


Fig 263. Porcupine teeth marks left in sapwood.

Bark is gnawed from trees rather than stripped. Basal girdling is more common on smaller trees, while debarking of the upper stem and major branches occurs on larger saplings to mature trees. Symptoms are generally evenly distributed on the upper bole and throughout the crown of these older trees. The sapwood is always deeply gnawed and prominent vertical and diagonal toothmarks approximately 2.5 mm wide can be seen. Small strips of bark may be found around the base of attacked trees. Some branch cutting may also occur. Attacked trees may display characteristic bushy crowns and spike-tops as a result of top girdling.

Fig 264. Top kill resulting from upper stem girdling.

Tracks are not prominent during the summer months but may be seen during winter in the snow, in the form of a trough-like trail that shows a drag mark from the tail and brush marks from the quills. Abundant droppings are usually found around recently attacked trees. Droppings are single or linked together in short chains. They are 2.5 cm long, narrow and curved, and have rounded ends.

DAMAGE:

Porcupine attacks on conifers can cause serious losses. Scattered mortality can occur over fairly extensive areas. Trees die when the lower portion of the stem is girdled. Annual mortality rates are estimated to be about 1% per year of the hemlock and spruce component in heavily damaged stands. Top kill, deformity, and reduced growth rate result from feeding activities on the upper stem and in the crown.

SIMILAR DAMAGE:

Stalactiform blister rust or atropellis cankers on mature lodgepole pine are sometimes mistaken for older porcupine damage. If close inspection is possible, look for the toothmarks of the porcupine.

BLACK BEAR

Ursus americanus (Pallas.)

DISTRIBUTION

Throughout BC.

Fig 265 Scattered mortality from bear damage.

TREE SPECIES ATTACKED:

All conifer species are susceptible. Trees that are pole-sized or larger are usually attacked, though occasionally saplings are damaged. Redcedar is the most susceptible species on the coast. Douglas-fir and western larch are often damaged in the interior. Damage usually occurs during the spring.

SIGNS & SYMPTOMS:

Bear damage is unique from that of other animals. Large sections of the bark are stripped from trees and lie around the tree bases. The exposed sapwood has long vertical grooves left by the canine teeth during feeding. Some debarking may be found in the crown, but most feeding is confined to the lower main stem. Rapidly growing, vigorous trees in moderately to lightly stocked stands are preferred. Resinosis and animal hair are sometimes found in association with damaged areas. Bear droppings are either a circular mass or are large and cylindrical.

BLACK BEAR

Tracks are large, and claw marks at the end of the five toes are usually very visible. Tracks left by the hind feet are oblong and resemble a human footprint, and those left by the fore feet are oval. Logs and stumps that are ripped apart, or claw marks on trees, may also be visible in the surrounding area.

Damage:

The incidence of bear damage is generally very scattered and associated with specific areas or drainages where local bears appear to have learned this behavior. Trees are usually killed due to the destruction of extensive areas of sapwood. In general, bear damage is much less frequent than damage caused by other animals.

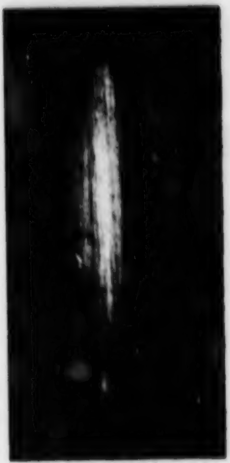


Fig 266. *Bears remove large strips of bark from lower bole and leave vertical grooves in the sapwood.*

PART 2

DAMAGE AGENTS OF BROADLEAF TREES IN BRITISH COLUMBIA

DAMAGE AGENTS OF BROADLEAF TREES IN BRITISH COLUMBIA

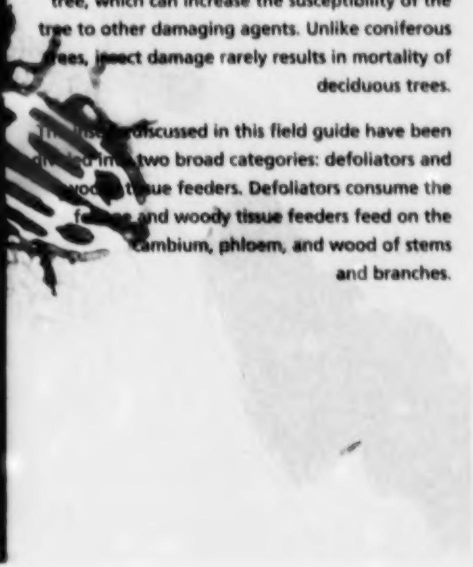
Damage agents of broadleaf trees in BC have not been studied as closely as those of conifers, which is reflected in the amount of information that is available on the subject. With the recent increase in the economic importance of broadleaf trees, the potential for damage agents to cause economic loss is changing. As plantations and nurseries are being established, the perceived significance of damage is likely to increase. New or overlooked damage agents will become significant and others will become less important as the industry evolves.

The agents discussed in this field guide are limited to those that have the potential to cause economic damage to commercial broadleaf trees. The broadleaf trees that are considered commercial in British Columbia are: red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), black cottonwood (*Populus trichocarpa*), balsam poplar (*Populus balsamifera*), and hybrid poplars (Massie et al, 1994).

Introduction to Insects of Broadleaf Trees

Many species of insects feed on deciduous trees in BC. Few of these insects, however, cause economically important damage. Certain insects may cause noticeable defoliation, but the concern is often nuisance or aesthetic rather than economic. The degree of injury depends on the insect species, the type of damage, the time of year, the part of tree attacked, as well as the health of the tree. Most of the damage results in a reduction in radial growth and a weakening of the tree, which can increase the susceptibility of the tree to other damaging agents. Unlike coniferous trees, insect damage rarely results in mortality of deciduous trees.

The insects discussed in this field guide have been divided into two broad categories: defoliators and woody tissue feeders. Defoliators consume the foliage and woody tissue feeders feed on the cambium, phloem, and wood of stems and branches.



DEFOLIATORS

Defoliators eat the leaves and buds of broadleaf trees. They are the most important and the most destructive insects damaging broadleaf trees. Defoliator outbreaks are typically sporadic, and pass through cycles of variable length and intensity. The defoliators of broadleaf trees belong to three different orders: Lepidoptera (moths), Hymenoptera (sawflies), and Coleoptera (leaf beetles). The larval stages are responsible for most of the damage.

Signs of damage by defoliators include holes or blotches in leaves, and skeletonized, rolled, or webbed leaves. Eggs can be seen on leaves, twigs, or branches. Larval skins or pupal cases can be found on leaves, and tents or nests can indicate the presence of certain species of moths. Broadleaf trees can withstand several years of defoliation without being seriously affected. When damage occurs early in the season, most trees are able to refoliate later in the summer. Heavy feeding may retard tree growth, cause branch dieback, and weaken the trees, making them more susceptible to other insects, diseases, frost, or drought. Defoliators rarely kill trees, unless defoliation carries on for more than two or three years.

AMBERMARKED BIRCH LEAFMINER

Profenusa thomsoni (Konow)

BIRCH LEAFMINER

Fenusa pusilla (Lepeletier)

DISTRIBUTION

Both species were introduced into North America from Europe. They are found throughout BC.

Fig 267. Ambermarked birch leafminer larva.

Fig 268. Birch leafminer larva.

Fig 269. White birch leaf mined by leafminers.

Fig 270. Egg punctures in birch leaf by ambermarked birch leafminer.

TREE SPECIES ATTACKED:

Paper birch is the primary host.

WHAT TO LOOK FOR:

Brown blotches on birch leaves with sawfly larvae between the two epidermal layers. Larvae are whitish with characteristic black markings on the underside.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are slightly flattened, have a whitish body with light-coloured heads, and are 0.6 to 0.7 cm long when fully grown. Dark coloured marks on the underside of the larvae can be used to distinguish between the two species. The ambermarked birch leafminer has a conspicuous midventral light-coloured patch on the prothorax, and a much smaller, dark patch on each of the other two thoracic segments. The birch leafminer has four midventral black dots, one on each of the three thoracic segments and one on the first abdominal segment. Ambermarked birch leafminer adults are tiny, black sawflies with characteristic white legs. Females are parthenogenetic, and no males have been found in North America. Birch leafminer adults are black with yellowish-brown legs. Males are rare and mating is not required.

AMBERMARKED BIRCH LEAFMINER

BIRCH LEAFMINER

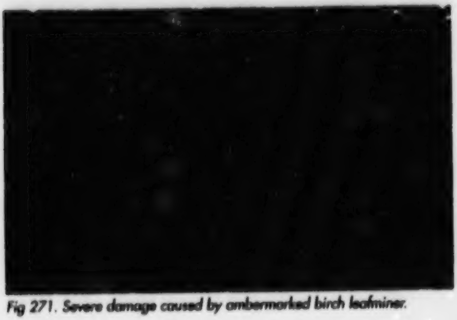


Fig 271. Severe damage caused by ambermarked birch leafminer.

The birch leafminer is the first leafminer to attack birch in the spring. Adults emerge and lay their eggs in late May and early June in slits cut on the upper surface of developing leaves, usually near the midribs, where small, light green or grey spots become visible. When the eggs hatch, the larvae begin to feed on the leaf tissue between the two epidermal layers. The spots on the leaves develop into brown blotches, which increase in size and eventually coalesce, covering most of the leaf. There are two to four generations each year. Eggs are never laid on mature leaves. In later generations, eggs are laid mainly at twig terminals where new leaves are produced. Ambermarked birch leafminer eggs are laid in July along the veins in the basal and central area of the leaves. Feeding by larvae causes brown blotches, which usually contain frass, similar to those caused by the birch leafminer. There is only one generation each year.

Fig 272. Ambermarked birch leafminer mines in white birch leaves.

Fig 273. Leaf mined by birch leafminer.

DAMAGE:

Mining by these leafminers causes the leaves to dry out and turn brown. Severe damage can result in stress, slight reduction in radial growth, and branch and top die-back.

ASPEN SKELETONIZER

Phratora purpurea purpurea Brown

COTTONWOOD LEAF BEETLE

Chrysomela scripta Fabricius

DISTRIBUTION

Both leaf beetle species are found throughout BC.

Fig 274. Aspen skeletonizer larvae and feeding damage.

Fig 275. Adult cottonwood leaf beetle.

Fig 276. Cottonwood leaf beetle larva.

TREE SPECIES ATTACKED:

The aspen skeletonizer feeds on aspen, black cottonwood, balsam poplar, hybrid poplars, paper birch, and red alder. The cottonwood leaf beetle attacks black cottonwood, hybrid poplars, and balsam poplar, but not trembling aspen. Both species also attack willow. Other leaf beetle species that feed on broadleaf trees are listed on page 217.

WHAT TO LOOK FOR:

Skeletonized leaves with intact veins; groups of grublike larvae with well-developed legs on the thorax but no legs on the abdomen.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Mature *Phratora* larvae are about 0.6 cm long. They are black and have legs on the thorax but not on the abdomen. Larvae are difficult to identify to species. Adults are unspotted, purplish to greenish metallic beetles, 0.4 to 0.5 cm long. Their wing covers have several rows of punctures, which distinguishes them from flea beetles. Mature *Chrysomela* larvae are about 1.2 cm long and have legs on the thorax but not on the abdomen. They have black heads, brownish dorsal thoracic plates, yellowish bodies with two rows of black spots along the back, and dark glands that can be turned outward, along each side of their abdomen. *Chrysomela* larvae are all quite similar, and adults are needed for species identification. Adult cottonwood leaf beetles are elongate-oval and are 0.5 to 1.0 cm long. They have a black head and the dorsal part of the first thoracic segment is black in the centre and reddish on the sides. The wing covers are yellowish with a dark line along the inner edges, and each one has seven elongate black spots.

Fig 277. Cottonwood leaf beetle larvae feeding on leaf.

Adult beetles emerge in the spring and feed on the tender shoots by chewing many small holes through the leaves. Females lay their eggs in clusters on the leaves. The gregarious larvae feed by skeletonizing the leaves, consuming the entire leaf tissue except the midrib and most veins. Trees defoliated by leaf beetles often have thin and ragged foliage or a scorched appearance. Adults also feed gregariously on foliage before overwintering in the soil.

Fig 278. Cottonwood leaf beetle eggs.

Damage:

These leaf beetles generally prefer young foliage, and high populations may kill shoots and cause deformed growth. Young trees may be killed. Damage is most prevalent in hybrid poplar plantations.

Similar Damage:

Leaf beetles typically do not consume the midrib or the veins. Other skeletonizers (moth and sawfly larvae) generally consume most veins, leaving only the midrib and the largest veins.

OTHER LEAF BEETLES

Several other leaf beetle species are common in B.C. and can be confused with the cottonwood leaf beetle and the aspen skeletonizer. Their damage is similar but is generally not significant.

LEAF BEETLE SPECIES	TREE SPECIES ATTACKED	INSECT DESCRIPTION
Aspen leaf beetle *Chrysomela crotchi* Brown	Mainly aspen, but also other poplars	Adults are 0.7 to 0.8 cm long. Their head and the dorsal part of the first thoracic segment are black, and their wing covers are light brown or brownish-yellow. Larvae resemble those of the cottonwood leaf beetle but are whiter.
Chrysomela falsa Brown	Balsam poplar	Adults are similar to aspen leaf beetle adults. They have brownish-yellow wing covers with black spots.
Alder flea beetle *Altica ambiens* LeConte	Alder	Adults are 0.6 cm long, shiny steel blue, and they jump when disturbed. They are similar to *Phratora* adults but without the rows of puncture on the wing covers. Larvae are black.

BRUCE SPANWORM

Operophtera bruceata (Hulst)

WINTER MOTH

Operophtera brumata (Linnaeus)

DISTRIBUTION

Bruce spanworm is found throughout BC. The winter moth was introduced into North America from Europe, and was first recorded in Canada in 1950, in Nova Scotia. It was first found in BC in 1977 on Vancouver Island, and is now found on southern Vancouver Island and the Lower Mainland.

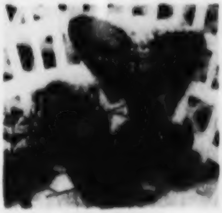


Fig 279. Adult male bruce spanworms.

Fig 280. Adult winter moths (male above, females below).

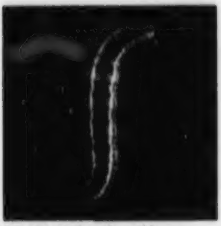


Fig 281. Light-coloured bruce spanworm larva.

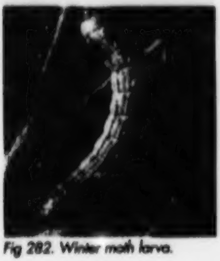


Fig 282. Winter moth larva.

Tree Species Attacked:

Trembling aspen, paper birch, balsam poplar, and bigleaf maple are attacked. The winter moth is also an important defoliator of Garry oaks on southern Vancouver Island. Willow and several other broadleaf tree species are also attacked.

What To Look For:

Hairless loopers feeding within rolled or webbed leaves. Also, bright orange eggs found either in bark crevices, under lichen, or in moss somewhere on the tree. A silken web on understory vegetation can also be observed.

Insect Description & Damage Symptoms:

Larvae of both species are stout-bodied, hairless loopers about 1.8 cm long when fully grown. Bruce spanworm larvae are typically light green with one prominent and two indistinct yellowish-white lines along the sides, with a dark brown head. Some individuals are darker in colour, having blackish heads and dark grey bodies with three whitish bands along each side. Winter moth larvae have a green body, a narrow, dark green mid-dorsal line, and three creamy yellow stripes along each side. Adult females are 0.6 to 0.8 cm long and have only vestigial wings. The vestigial wings of the female winter moth are about three times longer than those of the bruce spanworm (about 0.26 cm and 0.08 cm long, respectively). Some individuals are dull ocherous brown with white patches, and others have bluish-grey scales on their abdomens. Males are light brown, slender-bodied moths. They have bluish grey wings with brownish markings most noticeable on the veins, and a wingspan of 2.5 to 3.0 cm.

Fig 283. Bruce spanworm eggs.

Adults may be found from late October to the end of January. Females lay their eggs in the fall in bark crevices, under lichen, or in moss on any part of the tree. The eggs are light green at first, later changing to bright orange. Larvae hatch in the spring and initially feed by mining developing buds. This results in holes in the leaves, which become conspicuous as the leaves expand. Later, they feed either openly, or within rolled or webbed leaves. During severe outbreaks, trees and understory vegetation can become covered with webbing. There is one generation per year.

Fig 284. Trees defoliated by bruce spanworm. Note webbing on understory vegetation.

Damage:

Because feeding is completed early in the growing season, infested trees will produce new leaves. Outbreaks usually last 2 to 3 years and result in reduced radial growth. Tree mortality will result only if the outbreak lasts for several consecutive years. Garry oaks on southern Vancouver Island have been severely affected by the winter moth; however, defoliation has been greatly reduced by the introduction in 1979 to 1981 of two parasitoids, *Cyzenis albicans* and *Agrypon flaveolatum*, which were also introduced in south Vancouver in 1995.

Fig 285. Damage caused by bruce spanworm.

Similar Damage:

Damage caused by bruce spanworm can be confused with that caused by the large aspen tortrix. However, if the damage was caused by bruce spanworm, no pupal cases or egg masses will be found on the foliage, and no hibernation shelters will be present on stems and branches.

COTTONWOOD SAWFLY

Nematus currani Ross

DISTRIBUTION

Islands in the Fraser River near Chilliwack. It has also been collected in the Cariboo and Kamloops Forest Regions.

Fig 286. Cottonwood sawfly larva on leaf.

TREE SPECIES ATTACKED:

Black cottonwood and hybrid poplars are susceptible.

WHAT TO LOOK FOR:

Greenish-yellow sawfly larvae with yellow heads feeding on developing leaves early in the season.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are about 1.0 cm long, cylindrical, hairless, and uniform in diameter except for the tapered rear end. They have a yellowish head and a greenish yellow body with no distinct markings. Adults are 0.6 to 0.7 cm long. They have a black body with orange blotches on the back of the head, posterior to the eyes. Legs are yellow with black femurs.

Adults emerge very early in the spring. Larvae feed on developing leaves, and feeding is usually completed by May. The larvae spin a cocoon in which they overwinter. There is one generation per year.

DAMAGE:

Damage has only been reported on black cottonwood and hybrid poplars in the Chilliwack area. Defoliated trees generally refoliate by

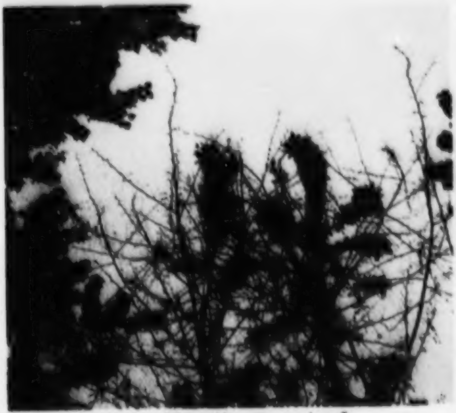


Fig 287. Hybrid poplars defoliated by cottonwood sawfly.

mid–summer. Several years of moderate to severe defoliation can cause reduction in radial growth and increased susceptibility of trees to root rots and other diseases.

Similar Damage:

This insect will generally consume the entire leaf tissue, except the largest veins. Leaves damaged by leaf beetles will have untouched veins.

FALL WEBWORM

Hyphantria cunea (Drury)

DISTRIBUTION

Widespread throughout the Fraser Valley, also found in the Okanagan and other interior locations.

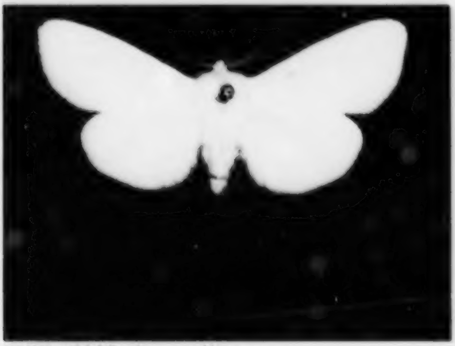


Fig 288. Adult fall webworm and larva.

TREE SPECIES ATTACKED:

Paper birch, black cottonwood, red alder and bigleaf maple are susceptible. The fall webworm also attacks willow and fruit trees.

WHAT TO LOOK FOR:

Trees with nests that have foliage enclosed, and inside which are found gregarious, hairy caterpillars with a broad black dorsal stripe, and small black and orange knob-like, fleshy protuberances on either side.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are about 2.5 cm long when fully grown. They have pale yellowish bodies with a broad black dorsal stripe. They have small black knob-like fleshy protuberances on the dorsal stripe and orange ones on either side, from which long silky hairs arise in tufts. Adults have a nearly white body, white wings usually without markings, and a wingspan of 3.0 to 4.0 cm.

Adults are found in June and July. Eggs are laid in masses of up to 300 on the underside of leaves, and are covered with white hairs from the female's abdomen. Young larvae web leaves together to

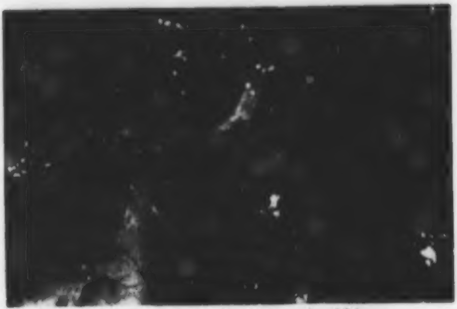


Fig 289. Fall webworm nests on walnut. Note enclosed foliage.

construct a nest, and the gregarious larvae feed throughout the summer on foliage enclosed by the nests. The nests are enlarged as the larvae grow, and they may enclose several branches. Pupation takes place in cocoons woven in bark crevices, beneath stones, or in the litter or soil, where pupae overwinter. There is one generation per year.

Fig 290. Fall webworm larva.

DAMAGE

High populations do not usually persist for more than 2 or 3 years, and healthy trees are unlikely to be killed. This insect causes little permanent damage.

SIMILAR DAMAGE

Fall webworm larvae are found in nests that enclose foliage. Northern tent caterpillar tents occur on branches and stem, enclose less foliage than fall webworm nests, and the larvae are found on the surface of the tents.

FOREST TENT CATERPILLAR

Malacosoma disstria Hübner

DISTRIBUTION

Throughout BC.

Fig 291. Adult forest tent caterpillar.

TREE SPECIES ATTACKED:

Mainly trembling aspen is attacked, but also black cottonwood, balsam poplar, red alder, hybrid poplars, and paper birch. Willow and apple are also attacked.

WHAT TO LOOK FOR:

Greyish egg bands on twigs and branches in winter; groups of larvae with characteristic keyhole-shaped dorsal spots feeding on leaves that are not webbed or rolled.

Fig 292. Forest tent caterpillar larva on bur oak.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are dark brown, hairy, and 4.5 to 5.5 cm long when mature. They have a prominent row of white keyhole-shaped dorsal spots, two fine orange lines on either sides of the white spots, and a broad, bluish lateral band below the lines. Moths are light to dark reddish-brown, stout, and hairy. The forewings have two dark oblique bands, and the wingspan is 2.5 to 4.5 cm.

Brown or grey (when weathered) egg bands covered with silvery-brown foam can be found encircling small twigs, from late summer to early spring. Larvae emerge in early spring when the buds swell, and

Fig 293. Trees defoliated by forest tent caterpillar.

feed gregariously on opening buds and on leaves. Fully grown larvae congregate on the trunk or on large branches, and will migrate to other broadleaf trees and shrubs if all the foliage is consumed. Unlike northern tent caterpillars, forest tent caterpillars do not form a tent, but spin a trail of silk wherever they go. Mature larvae spin cocoons between leaves or in any sheltered place, and pupate in these cocoons.

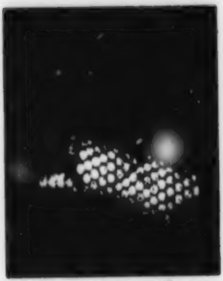


Fig 294. Forest tent caterpillar eggs. Note foam cover was removed to expose eggs.

Damage:

Infestations usually occur about every 10 years, and last 3 to 5 years. One or more years of severe defoliation may result in top-kill, branch mortality, reduced radial growth, and if the infestation persists, occasional mortality. Significant tree mortality has not been recorded. Severely defoliated trees usually refoliate in mid-summer.

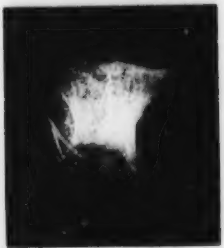


Fig 295. Forest tent caterpillar cocoon on aspen.

LARGE ASPEN TORTRIX

Choristoneura conflictana (Walker)

Distribution

Throughout the range of aspen, most common in Prince George, Prince Rupert, Nelson Forest Regions, and southwestern Yukon Territory.

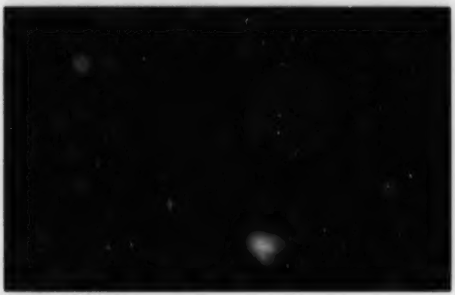


Fig 296. Adult large aspen tortrix.

Tree Species Attacked:

Trembling aspen and balsam poplar are susceptible.

What To Look For:

Dark, smooth caterpillars feeding within rolled or webbed leaves; egg masses on foliage.

Fig 297. Large aspen tortrix larva.

Insect Description & Damage Symptoms:

Young larvae are 0.3 to 0.4 cm long. They have black heads, and yellowish or pale green bodies that become progressively darker with each molt. Mature larvae are 1.5 to 2.1 cm long, and are dark green, almost black in colour. Adult moths are brownish grey, and the forewings are light grey with three patches of darker grey. They have a wingspan of 2.5 to 3.5 cm.

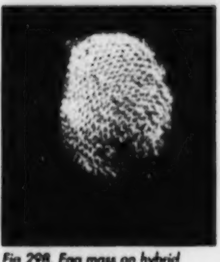


Fig 298. Egg mass on hybrid poplar leaf.

Overwintered larvae emerge and begin mining the buds in early spring, but the damage caused at this time is usually inconspicuous. However, during severe infestations, there might be a delay in the opening of buds, or buds may be completely destroyed, so no foliage is produced. Older larvae feed within rolled leaves, or pull two or more leaves together with silken threads and feed within the folded leaves. Affected foliage has a clumped, irregular appearance. Pupation occurs in mid-June,

Fig 299. Empty pupal cases protruding from webbed leaves.

and the adult moths emerge about 10 days later. The empty pupal cases can often be seen protruding from the clumps of folded leaves. Light green eggs are laid in clusters on the upper surface of the leaves, and appear as overlapping scales. They hatch in about 2 weeks. The young larvae web leaves together and feed on the leaf tissue. In mid-August, they will cease feeding and construct silken hibernation shelters underneath bark scales, dead bark, or moss on tree stems and branches.

Fig 300. Aspen leaves webbed together by large aspen tortrix.

DAMAGE:

Infestations usually last 2 to 3 years, recurring about every 10 years. Severe defoliation can result in reduced radial growth, but only rarely results in tree mortality. Outbreaks of the large aspen tortrix tend to precede those of the forest tent caterpillar.

SIMILAR DAMAGE:

Damage caused by the large aspen tortrix can be confused with that caused by the bruce spanworm. However, if the damage was caused by the large aspen tortrix, pupal cases or egg masses will be found on the foliage, and hibernation shelters will be present on nearby stems and branches.

Fig 301. Defoliation by large aspen tortrix. Note webbing on understory vegetation.

NORTHERN TENT CATERPILLAR

Malacosoma californicum pluviale (Dyar)

DISTRIBUTION

Southern half of BC.

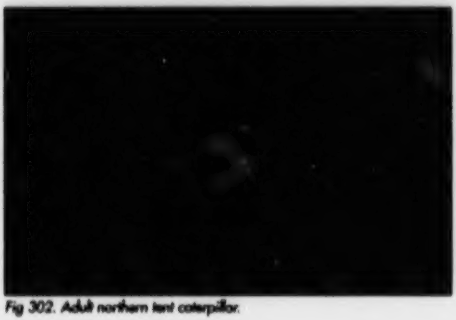


Fig 302. Adult northern tent caterpillar.

TREE SPECIES ATTACKED:

A wide range of broadleaf hosts are susceptible, including red alder, black cottonwood, paper birch, balsam poplar, hybrid poplar and trembling aspen. Willow and fruit trees are also attacked.

WHAT TO LOOK FOR:

Conspicuous silken tents on branches and stems, from which caterpillars feed gregariously on the foliage.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Fully grown larvae are 4.5 to 5.5 cm long. They have a dark brown body, which is not conspicuous because of prominent markings that can vary highly between individuals. An average specimen has a series of narrow, light blue-grey elliptical patches along the midline of the back, corresponding to each body segment. Each of these is bracketed by a pair of orange patches, and a pair of blue dots lower down on the sides. A single orange stripe runs beneath these patterns, low on the sides of the body. Adult moths range in colour from pale yellow to dark reddish-brown, and have a wingspan of 2.5 to 3.7 cm. When open, the wings have a single dark line that radiates at right angles to the body, bisecting the forewing. Two lighter lines running parallel to the outer edge of the forewings divide them into three segments.

Fig 303. Northern tent caterpillar larva.

NORTHERN TENT CATERPILLAR

Fig 304. Northern tent caterpillar larvae on tent.

Eggs hatch in the spring at the time of budbreak. Young larvae are gregarious and spin a large silken tent in the crotch of a branch from which they feed on new foliage. Tents are enlarged and defoliation intensifies as the larvae mature. Trees often become stripped of foliage by mid-June or early July. Just prior to pupation, larvae wander away from the host tree, and can be seen crawling in all directions in search of a suitable pupation site.

DAMAGE:

Significant damage occurs only after prolonged severe infestations, and is limited primarily to loss of growth potential and some branch dieback. Defoliated trees usually refoliate in mid-summer, but leaves are often smaller. Trees weakened by repeated defoliation are more susceptible to secondary effects such as infection by fungi, drought, and frost.

SIMILAR DAMAGE:

Northern tent caterpillar tents are found on branches and stems, with larvae occurring on the surface of the tents. Fall webworm larvae, by contrast, are found inside nests which enclose more foliage than northern tent caterpillar tents.

SATIN MOTH

Leucoma salicis (Linnaeus)

DISTRIBUTION

The satin moth was introduced into North America from Europe. It was first detected in BC in 1920, and is now found on Vancouver Island, in the Fraser Valley, and throughout the southern and central interior of BC (Vancouver, Kamloops, Nelson, Cariboo, and Prince George Forest Regions).

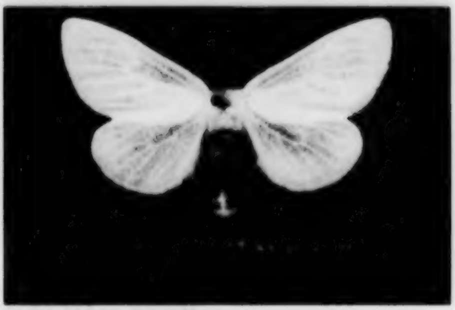


Fig 305. Adult satin moth and larva.

TREE SPECIES ATTACKED:

Black cottonwood, hybrid poplars, and trembling aspen are attacked. The satin moth also feeds on willow.

WHAT TO LOOK FOR:

Caterpillars with characteristic yellowish blotches and lines, and rows of tufted brownish setae; cast skins on the underside of branches, rolled leaves containing pupae, and silk webbing on stems and branches.

Fig 306. Satin moth larva.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are 3.5 to 4.5 cm long when fully grown, and are pale to medium grey-brown, with a darker head and back. They have one row of large, oblong, double, shiny yellowish blotches along the middle of the dorsal surface and two subdorsal, broken, yellowish lines. They also have two lateral and two subdorsal rows of tufted brownish setae. Adults are large silvery white moths with a dark body showing through the hairs. They have a wingspan of 3.0 to 5.0 cm.

Overwintered larvae emerge and begin feeding in late April. Damage is most conspicuous in June when late instar larvae consume whole new leaves, except

SATIN MOTH

Fig 307. Severe defoliation caused by satin moth.

the petioles and major veins. Larvae molt on the underside of branches, and cast skins are conspicuous there. Pupae are found in loosely woven silken cocoons in rolled leaves, on twigs, or in bark crevices. Adults emerge in July, and flat light green eggs are laid in masses with a whitish secretion from early July to late August on leaves, twigs, branches, and trunks of host trees, or indiscriminately on other objects. Larvae emerge in about two weeks. First and second instar larvae skeletonize foliage for about two weeks in late summer, and in severe infestations, leaves turn brown and drop.

Fig 308. Satin moth egg mass. Note white secretion was removed to expose the eggs.

Damage:

Satin moth infestations often occur together with infestations of other defoliators, such as tent caterpillars (*Malacosoma* spp.). Satin moths can completely defoliate trees, and repeated severe defoliation can result in reduced radial growth, top-kill and tree mortality.

Fig 309. Satin moth larva and feeding damage.

Similar Damage:

Damage is similar to that caused by other skeletonizing moth or sawfly larvae. Rolled leaves containing pupae and silk webbing on stems and branches are characteristic of the satin moth.

STRIPED ALDER SAWFLY

Hemichroa crocea (Geoffroy)

DISTRIBUTION

Throughout BC, but most common on the coast.

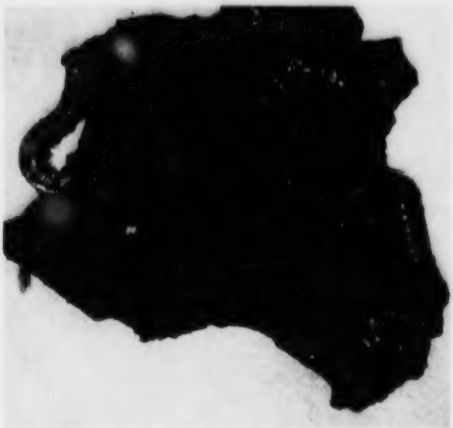


Fig 310. Striped alder sawfly larvae, feeding on leaf.

TREE SPECIES ATTACKED:

Red alder and occasionally paper birch are attacked. The striped alder sawfly is also found on willow.

WHAT TO LOOK FOR:

Skeletonized leaves and yellowish sawfly larvae with black heads and dark brown subdorsal stripe and blotches.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae are about 2.0 cm long when fully grown. They have a shiny black head and a yellowish body marked by a dark brown subdorsal stripe, and two lateral rows of blotches. Adults are medium-sized nondescript sawflies.

Eggs are laid in a row of slits cut on either side of the midrib on the underside of the leaves. Larvae feed gregariously, initially eating holes through the leaf from the underside, giving it a characteristic riddled appearance. Eventually, the entire leaf is consumed except the larger veins. Striped alder sawflies overwinter as prepupae in cocoons in the soil. There are two generations each year.

DAMAGE:

This sawfly periodically causes heavy defoliation on the coast, virtually stripping the foliage from extensive stands. This can potentially result in reduced growth of attacked trees, but damage is seldom any worse than this.

SIMILAR DAMAGE:

Damage may be similar to that caused by the woolly alder sawfly. The larvae will help in determining which species is responsible for the damage. Leaves skeletonized by leaf beetles, however, will still have all the veins, even the smallest ones.

WESTERN WINTER MOTH

Erannis tiliaria vancouverensis Hulst

DISTRIBUTION

Throughout BC, west of the Rockies.

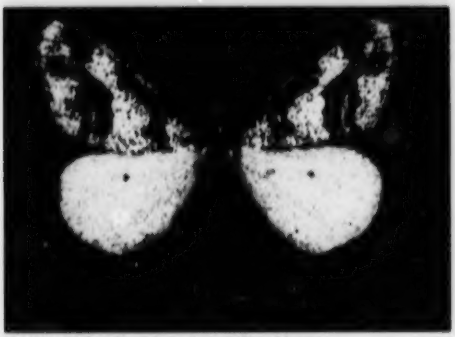


Fig 311. Adult male western winter moth and larva.

Tree Species Attacked:

Bigleaf maple is the preferred host on the coast. Paper birch, red alder, trembling aspen, black cottonwood, and Garry oak are also attacked.

What To Look For:

Yellow-brown loopers with irregular dark brown lines feeding on developing leaves early in the spring; frayed and tattered foliage.

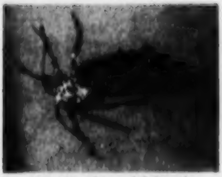


Fig 312. Wingless adult female western winter moth.

Insect Description & Damage Symptoms:

Larvae are yellow-brown loopers with irregular dark brown lines, and orange-brown heads, dorsal thoracic plates, and legs. They are 1.6 to 4.1 cm long when fully grown. The life cycle is characterized by the seemingly unseasonable appearance of the adults, which may emerge mid-September to early April. Males are pale silvery-grey with variegated brownish stipple and a wingspan of 3.1 to 4.0 cm. Females are wingless and have a finely scaled, pale, brownish-ivory abdomen with many black markings.

Eggs are laid in small scattered clusters concealed on the bark and twigs of the host tree. They hatch after leaf buds have opened, usually during May or June.

WESTERN WINTER MOTH

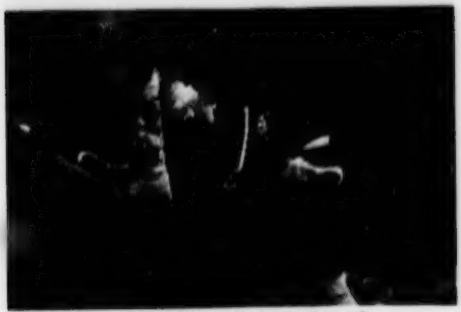


Fig 313. Western winter moth larvae feeding on vine maple.

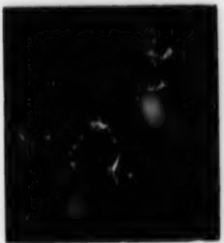


Fig 314. Damage caused by western winter moth larvae.

The young larvae tend to be gregarious for a few days and are relatively light feeders, removing small sections of margin and/or surface from the leaves. As the larvae grow they disperse over nearby branches, but seldom leave their original tree. The period of heaviest feeding coincides with the expansion of the new leaf growth early in the spring. Leaves on infested trees characteristically appear frayed and tattered and, as feeding starts before the leaves mature, the amount of defoliation often seems exaggerated.

DAMAGE:

This insect may cause severe defoliation of broadleaf trees in localized areas, but seldom causes any long-term damage.

Fig 315. Bigleaf maple defoliated by western winter moth.

WOOLLY ALDER SAWFLY

Eriocampa ovata (Linnaeus)

DISTRIBUTION

The woolly alder sawfly is an introduced species of European origin. In BC, it is found in Vancouver, Prince George, Prince Rupert, and Nelson Forest Regions.

Fig 316. Woolly alder sawfly larva.

TREE SPECIES ATTACKED:

Red alder is attacked on the coast. Other alder species are also attacked.

WHAT TO LOOK FOR:

Skeletonized leaves and sawfly larvae covered with a white woolly secretion, or white molted skins on branches of damaged trees.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

Larvae have greyish heads and pale green bodies, both of which are covered with a white, woolly secretion. They are 1.3 cm long when mature.

Adults emerge from late May to July, and females lay their eggs along the main vein of the leaves. Larvae consume the whole leaf except the major veins. They spin cocoons in the soil, duff, or wood where they overwinter as pre-pupae. Some larvae, however, spin cocoons and continue to develop to the adult stage to produce a second generation.

WOOLLY ALDER SAWFLY

Fig 317. Damage caused by woolly alder sawfly.

DAMAGE:

Damage can be severe on young alder seedlings and saplings. However, the current year's apical growth is usually untouched. On older trees, damage is usually inconsequential.

SIMILAR DAMAGE:

Damage may be similar to that caused by the striped alder sawfly. The larvae will help in determining which species is responsible for the damage. Leaves skeletonized by leaf beetles, however, will have even the smallest veins remaining.

WOODY TISSUE FEEDERS

Woody tissue feeders generally attack trees that are stressed, very young, or over-mature. Adults lay their eggs somewhere on or in the bark. Larvae are responsible for most of the damage. They bore through the bark and feed on the inner layers of the bark and on the wood.

Trees damaged by these insects are usually easy to recognize. Signs of damage include emergence holes, boring dust and resin on the bole, piles of shavings around the base of the tree, and tunnels with larvae under the bark.

Three species, all belonging to the order Coleoptera, are described in this section.

BRONZE BIRCH BORER

Agrilus anxius Gory

Distribution

Kamloops, Nelson, and Vancouver Forest Regions.

Fig 318. Adult bronze birch borer.

Tree Species Attacked:

Paper birch is the major host species.

What To Look For:

Creamy-white legless grubs in galleries packed with frass under the bark, generally on smaller branches and stems of declining trees; D-shaped emergence holes with no frass on the bark.

Fig 319. Bronze birch borer larva.

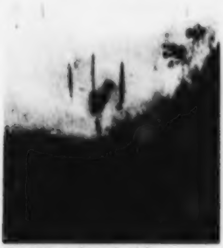


Fig 320. D-shaped adult emergence hole.

Insect Description & Damage Symptoms:

Larvae are flattened, creamy-white, legless grubs with light brown heads deeply embedded into the prothorax. They have two dark brown dorsal spines on the posterior part of their body, and are 3.5 cm long when mature. Adults are slender, olive-green to black beetles with metallic bronze reflections, 0.6 to 1.1 cm long.

The bronze birch borer requires 1 to 2 years to complete its life cycle. Adults emerge through D–shaped exit holes, beginning in June. Eggs are laid under bark scales or in bark crevices on sunny locations on the stem of weakened trees. Larvae burrow into the cambium and construct meandering tunnels in the phloem, occasionally penetrating into the wood. Smaller branches and the stem are usually attacked first, and early signs of the presence of larvae may include chlorotic leaves and sparse

Fig 321. Tree attacked by bronze birch borer.

foliage in the upper crown. The presence of larvae is confirmed by peeling the bark to reveal tunnels filled with packed, digested sawdust. Larvae that bore into vigorous trees are usually unsuccessful, and tunnels subsequently heal over with callus tissue, which gives the bark a bumpy appearance.

Fig 322. Bronze birch borer larval galleries.

DAMAGE:

The bronze birch borer usually attacks weakened trees. Infestations will result in top-kill and reduced radial growth. Repeated attacks can kill trees, mainly younger ones. There may be an association between the insect and root diseases (armillaria root disease in particular). The bronze birch borer is a significant urban pest.

Fig 323. Bumps on bark caused by callused tissue growth over galleries.

POPLAR BORER

Saperda calcarata Say

DISTRIBUTION

Vancouver, Prince George, Cariboo, Kamloops, and Nelson Forest Regions.

Fig 324. Adult poplar borer.

TREE SPECIES ATTACKED:

Trembling aspen, black cottonwood, and balsam poplar are the major host species. Willow is also attacked.

WHAT TO LOOK FOR:

Varnish-like resin and holes with boring dust on the stems; larval galleries with larvae under the bark.

Fig 325. Poplar borer larva.

POPLAR BORER

Insect Description & Damage Symptoms:

Larvae are up to 5.0 cm long when fully grown. They are legless grubs, and have creamy-white bodies with brown heads and brown dorsal thoracic plates. Adults are elongate, robust, greyish beetles. They are about 2.5 cm long, as are the antennae. Their body is densely stippled with small brown dots, and they have faint yellow stripes on the thorax and yellow blotches on the wing covers.

Fig 326. Poplar borer galleries under trembling aspen bark.

The poplar borer requires 3 to 5 years to complete development. Adults emerge in late June or early July and begin to lay eggs about one week after emergence. Females cut crescent-shaped notches into the bark, usually on exposed parts of the tree, where they deposit one or two eggs. Young larvae mine into the bark for the rest of the summer and remain there for the winter. The following spring, they enter the sap and heartwood, where they feed for two years. Varnish-like resin flowing down the stems and staining the bark, and boring dust exuding from holes, are the first signs that a tree is infested by the poplar borer. If the bark is removed, larvae and their galleries can be seen. They typically tunnel in larger branches and in the stem down to the root collar. Bark of trees previously infested by poplar borers is marked by crevices and fissures as a result of larval feeding and woodpecker damage.

Fig 327. Poplar borer damage on aspen. Note resin flow staining the bark.

Damage:

Damage is more prevalent in open than in dense stands. Young trees (7 to 10 cm in diameter) and trees growing on poor sites are usually favoured. Trees are usually not killed by the poplar borer, but stems are weakened and susceptible to breakage.

Similar Damage:

The damage could be confused with that of the poplar and willow borer. However, the poplar and willow borer rarely attacks trembling aspen.

POPLAR AND WILLOW BORER

Cryptorhynchus lapathi (Linnaeus)

DISTRIBUTION

This species was introduced into North America from Europe. In BC, it is most common on Vancouver Island, the Lower Mainland, and the southern interior valleys. Farther north, it is found south of 57 degrees north latitude, and populations are limited primarily to Bella Coola, Skeena, and Nass river valleys, and the northern Fraser River drainage around Prince George.

Fig 328. Adult poplar and willow borer.

TREE SPECIES ATTACKED:

Willow is the preferred host, but this borer also attacks poplar species (mainly black cottonwood, balsam poplar, and hybrid poplars). Trembling aspen and paper birch are rarely attacked.

WHAT TO LOOK FOR:

Upper crown or whole tree broken over or dead; irregular splits and holes in the bark, through which red-brown and white shavings exude; piles of shavings around the base of the stems.

INSECT DESCRIPTION & DAMAGE SYMPTOMS:

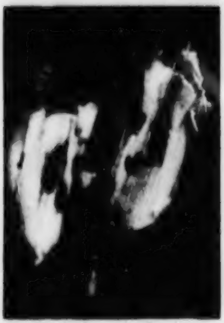


Fig 329. Poplar and willow borer larvae in willow stem.

Larvae are C-shaped, legless grubs. Their body is creamy-white with a brown head. They are about 1.3 cm long when mature. Adults are stout weevils with long curved snouts, and are 0.8 to 1.0 cm long. Their body is predominantly black, and their back is densely covered with tiny black and either grey or pink scales, which form an irregular band.

The life cycle takes up to three years, with the first winter spent as a young larva. Females oviposit during the summer in deep holes chewed in the bark on the lower part of the stems. The young larvae burrow in the inner bark at first, then enter the wood, where they excavate extensive, meandering tunnels, pushing the borings to the outside of the stem. Current damage by the larvae is indicated by

Fig 330. Crown symptoms of trees damaged by poplar and willow borer.

Fig 331. Poplar and willow borer emergence holes on willow stem.

Fig 332. Stem damaged by poplar and willow borer.

irregular splits and holes in the bark of host trees, through which sap and moist red-brown and white shavings exude, and by piles of shavings around the base of the stems. If infested stems are split open, larvae and their tunnels are visible. Previously infested stems are indicated by the presence of circular (0.3 to 0.4 cm diameter) emergence holes, darkened weathered tunnels, and calluses over injured areas. Most damage is done by the larvae, and attacked trees normally range from 2 to 8 cm in diameter. Adults also cause some injury by feeding on branches and on main stems, showing a preference for young succulent bark.

DAMAGE:

Larval feeding weakens the stems of host trees, making them susceptible to breakage. Damage to hybrid poplar plantations is of most concern. Clones range from resistant to highly susceptible, and damage is the greatest on trees 2 to 3 years old. This insect can also pose problems in a nursery setting.

SIMILAR DAMAGE:

The damage is similar to that caused by the poplar borer, but the poplar borer prefers trembling aspen.

Introduction to Diseases of Broadleaf Trees

Diseases of commercial broadleaf trees can affect all areas of the tree, ranging from their root system up to the foliage. Foliar diseases, as foliar insects, produce the same level of damage. Both can be short-lived and cause aesthetically unappealing defoliation, but neither will normally produce damage of economic importance. The stem and root diseases can be present in the trees for decades and cause extensive decay. These diseases are considered the most economically important.

In this section, the diseases are divided into four categories: heartrots, canker diseases, foliar diseases and shoot blights, and root diseases.

HEART ROTS

Heart rots are diseases of the main stem. They are often spread by windborne spores, which enter trees via branch stubs, and pre-existing cankers and wounds. The detection of heartrot diseases in a stand can be difficult. They can be present in trees for many years before characteristic fruiting bodies are produced. Most of the heartrots affecting broadleaf trees are classified as white rots because of their ability to break down wood cellulose and lignin.

Heart rots are the most economically important of the diseases. Their staining and decay capabilities reduce wood quality and thus, their marketability.

ASPEN TRUNK ROT

Phellinus tremulae (Bondartsev) Bondartsev & Borisov

DISTRIBUTION

Common throughout the range of aspen in BC.

Fig 333. Fruiting body of Phellinus tremulae on aspen.

TREE SPECIES ATTACKED:

Trembling aspen is the major host.

WHAT TO LOOK FOR:

Large, triangular-shaped, fruiting bodies (conks) on the stem.

SIGNS & SYMPTOMS:

FRUITING BODIES: The conks are perennial, triangular in longitudinal section, and can reach dimensions of 15 cm in height and 20 cm in width. The upper and lower surfaces slant upwards approximately 45 degrees. The upper conk surface is grayish black to black and deeply zoned. It will roughen and crack vertically with age. The lower surface is purplish-brown and porous. The rust-brown interior of the conk is filled with distinct tube layers that are streaked with white mycelium. The conk age can be determined from the number of tube layers.

Fruiting bodies appear at branch stubs or wounds on living and dead standing trees, and on slash. Presence of fruiting bodies (even one) indicates that a considerable volume of the tree is decayed. Black, blind conks (sterile mycelial masses) formed at branch scars are an additional external indicator of aspen trunk rot. The fungus is spread via windborne spores that invade exposed dead tissues.

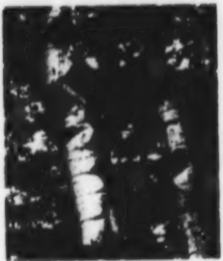


Fig 334. Sterile fruiting bodies on aspen trees.

DECAY: This fungus causes a white heart rot. It often produces a long decay column that continues throughout most of the main stem, and the decay usually occurs more than 2 m above ground level. Distinguishing characteristics of the decay are thin black lines bordering decay columns, with the surrounding wood stained reddish-brown.

In advanced stages of decay, the wood inside the zone lines becomes soft and yellow-white in colour with fine black zone lines running throughout. The decayed wood produces a wintergreen odour when cut.

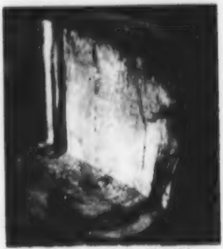


Fig 335. Cross-sectional and longitudinal view of advanced decay in trembling aspen caused by Phellinus tremulae.

DAMAGE:

This is the most common and most damaging cause of stain and decay in trembling aspen in BC. It lowers wood value in the incipient stage of decay by causing a red-brown stain, and later becomes structurally damaging as a white heart rot. It is estimated to cause 90 to 95% of aspen wood yield loss in northeastern BC. Volume losses increase significantly with tree age, particularly in stands over 30 years old. This disease may vary considerably from one stand to another, with decay lowest in more thrifty trees, perhaps as a result of interclonal variations. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Decay and fruiting bodies of aspen trunk rot are very similar to hardwood trunk rot. However, the former is only found on aspen, while the latter occurs on other hardwoods.

HARDWOOD TRUNK ROT

Phellinus igniarius (L:Fr.) Quél.

DISTRIBUTION

Common throughout the range of its hosts in BC.

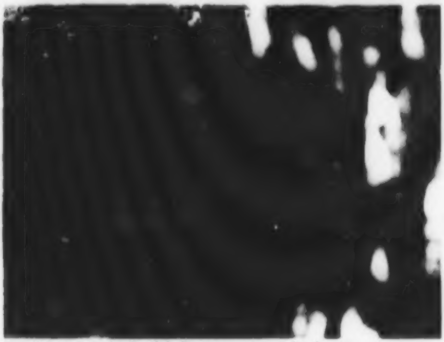


Fig 336. Fruiting body of Phellinus igniarius on birch stem.

TREE SPECIES ATTACKED:

Paper birch, black cottonwood, red alder (rare), and bigleaf maple are the major hosts.

WHAT TO LOOK FOR:

Large, hoof-shaped, perennial fruiting bodies (conks) on stem.

SIGNS & SYMPTOMS:

FRUITING BODIES: Conks are perennial, woody, and generally hoof-shaped. The upper surface is zoned, grey to black, and will roughen and crack vertically with age. The lower surface is brown and velvety, with small pores. The conk interior is rusty-brown with distinct tube layers flecked with white mycelium. Fruiting bodies form on living and dead standing trees and slash, and are associated with branch stubs or wounds. Fungal spread is via windborne spores that invade exposed dead tissues.

DECAY: This fungus causes a white heart rot. Distinguishing characteristics are thin black lines bordering decay columns, with surrounding wood stained reddish-brown.

Fig 337. Phellinus igniarius fruiting body.

In advanced stages of decay, the wood inside zone lines becomes soft, yellow-white with fine black zone lines running throughout. Decay symptoms are very similar to those of aspen trunk rot.

DAMAGE:

The fungus has an economic impact on host trees grown for timber and pulp. It also raises safety concerns in recreation sites. The presence of a single fruiting body generally indicates a considerable volume of decay. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Decay symptoms and fruiting bodies can be confused with those of *P. tremulae*, but *P. ignarius* is found on other hardwoods, while *P. tremulae* is restricted to aspen. Fruiting bodies are also very similar to those of *Fomes fomentarius*, but the upper conk surface of *P. ignarius* is dark, rough in texture, and cracked, while that of *F. fomentarius* is light grey and smooth.

WHITE SPONGY TRUNK ROT

Fomes fomentarius (L.:Fr.) J. Kickx fils

DISTRIBUTION

Widely distributed throughout the range of its hosts in BC.

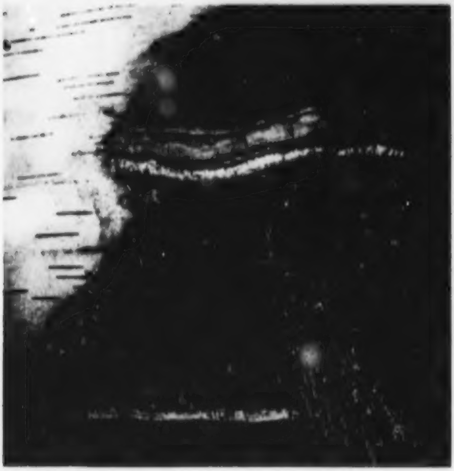


Fig 338. Fruiting bodies of Fomes fomentarius on birch stem.

TREE SPECIES ATTACKED:

Paper birch, balsam poplar, black cottonwood, and red alder (rare) are the major hosts.

WHAT TO LOOK FOR:

Hoof-shaped fruiting bodies (conks) on stem.

SIGNS & SYMPTOMS:

Whity spongy trunk rot is also known as Fomes trunk rot of paper birch and tinder fungus.

FRUITING BODIES: Conks are found on living and dead standing trees and slash. They are perennial, woody or leathery, hoof-shaped structures. The upper surface is smooth, grey to brown or black, and zoned (indicating perennial growth). The lower surface is concave, pale brown, and has small, regular-shaped pores (4 to 5 per mm). The interior is brown with distinct tube layers that are produced annually. The fungus is spread by windborne spores

Fig 339. Cross-section of fruiting body, illustrating the brown context.

that invade exposed dead tissues, such as branch stubs and stem scars.

DECAY: Incipient decay causes a light brown wood discolouration, with the wood remaining solid and sound. As decay matures, the wood turns yellow-white and becomes soft and spongy. The white rot can be present in both the sapwood and heartwood. Brown to black zone lines often appear with decayed wood. Radial cracks in the decayed wood may fill in with yellow mycelium, giving wood a mottled appearance.

DAMAGE:

Fomes fomentarius causes decay in living and dead timber. Visible fruiting bodies indicate there is little merchantable heartwood left. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Fomes fomentarius and *Phellinus ignarius* produce similar decay damage and fruiting bodies. Conks of *Fomes fomentarius* are pale grey and smooth, while *P. ignarius* conks are dark, rough and cracked.

WHITE MOTTLED ROT

Ganoderma applanatum (Pers.) Pat.

DISTRIBUTION

Throughout the range of its hosts in BC.

Fig 340. Fruiting body of Ganoderma applanatum on black cottonwood.

TREE SPECIES ATTACKED:

The major hosts are bigleaf maple, red alder (rare), paper birch, balsam poplar, trembling aspen, and black cottonwood.

WHAT TO LOOK FOR:

Flat or plate-like fruiting bodies (conks) with a tan lower surface that turns permanently reddish-brown when bruised or marked.

SIGNS & SYMPTOMS:

FRUITING BODIES: Perennial, flat, or plate-like conks are found on the lower stem of dead standing trees, cut ends of logs, and exposed roots. Conks are rarely found on living trees. The upper surface is light brown, concentrically ridged, and often covered with a dusting of brown spores. The interior is chocolate-brown, with annual pore layers. The lower surface and margin are usually white when fresh. The lower surface will turn brown as it ages or when it is bruised or marked. The fungus is spread by windborne spores. The presence of conks indicates extensive decay.

WHITE MOTTLED ROT

Fig 341. Late stages of decay caused by Ganoderma applanatum.

DECAY: The incipient stage of decay is indicated by a bleached appearance of the wood, surrounded by a dark brown stain. In advanced stages, the bleached wood becomes white, mottled, and spongy. Black zone lines are not always present in the decayed wood. The decay can be present in the roots or butts of living or dead trees and will often extend up into the trunk.

DAMAGES

Ganoderma applanatum can decay heartwood of living trees by entering through wounds and can cause extensive damage. It is an important decay organism of dead trees, especially on moist sites. Trees with conks should be considered hazardous.

BROWN CUBICAL ROT OF BIRCH

Piptoporus betulinus (Bull.:Fr.) P. Karst.

DISTRIBUTION

Found throughout the range of birch.

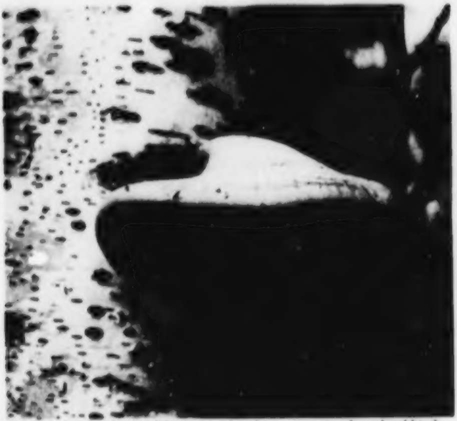


Fig 342. Fruiting body of Piptoporus betulinus *on a standing dead birch stem. Note curved-in cap margin.*

TREE SPECIES ATTACKED:

Birch is the only host.

WHAT TO LOOK FOR:

Leathery, brown, annual fruiting bodies with a short, thick stalk and a curved-in cap margin. Yellowish-brown decayed wood that breaks up into cubes or crumbles into powder.

SIGNS & SYMPTOMS:

FRUITING BODIES: Mushroom-like fruiting bodies are produced annually. They are leathery, with a short, stout stalk. The cap can reach dimensions of 15 cm deep, 25 cm wide, and 6 cm high. The upper surface is initially light brown, but becomes dark brown and scaly with age. The cap margin curves inward and extends beyond the pore surface. The pore layer is initially white but turns light brown with age. Pores are small and circular with 3 to 5 pores per mm. The interior of the conk is white and firm.

BROWN CUBICAL ROT OF BIRCH

Fig 343. An older Piptoporus betulinus fruiting body on a fallen birch stem. Note dark brown, scaly appearance.

DECAY: In later stages of decay, sapwood and heartwood are yellowish-brown and will separate into cubes. White, thin mycelial mats can form in between the cracks that delineate the cubes. Very advanced decay will crumble into a powder. This is one of the few brown rots that attacks only hardwoods.

DAMAGE:

Piptoporus betulinus is often found in dead branches of dying trees. After tree death, the decay spreads to the bark and sapwood. It continues to advance to the centre of the trunk. The extent of damage caused by this fungal species is unknown. Trees with fruiting bodies should be considered hazardous.

CANKER DISEASES

Canker diseases can be either opportunistic (those that attack weakened trees) or primary (those that attack healthy trees). Cankers range in size from 1 cm to a metre long on the stem.

The host tree may produce callus tissue in response to infection, depending on the aggressiveness of the disease.

The tree may eventually die from girdling or from stem breakage at the canker area.

Trees with cankers are of less value due to discolouration and reduced wood strength.

STERILE CONK TRUNK ROT OF BIRCH

Inonotus obliquus (Pers.:Fr.) Pilát

DISTRIBUTION

Widely distributed throughout the range of its hosts.

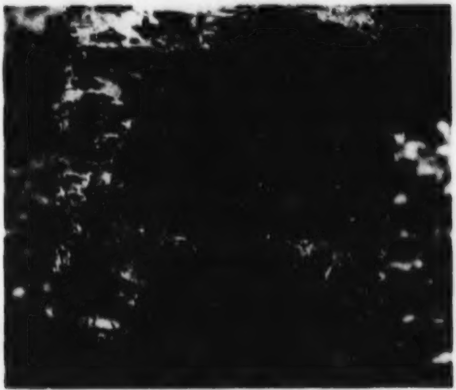


Fig 344. Large sterile conk of Inonotus obliquus on paper birch.

TREE SPECIES ATTACKED:

Paper birch is the major host. Black cottonwood is occasionally attacked.

WHAT TO LOOK FOR:

Sterile conks comprised of large black masses of tissue.

FRUITING BODIES: The fungus produces sterile conks. These are large (20 to 30 cm diameter), black, perennial masses of fungal tissue, which erupt from bark cankers. The conk surface is rough and cracked, and the internal tissue of the conk is yellow-brown to rust-brown and cork-like in texture. The tree trunk is often swollen at the conk area.

The fertile fruiting bodies are produced only on dead trees in the summer and early fall and are less conspicuous than sterile conks. They originally form under the bark or on outer wood layers that surround the sterile conk on dead trees. As development occurs, the bark and outer wood rings separate and lift away to expose the spore-bearing surface. The fruiting body is flat, 1 to 3 mm thick, and has grey to reddish-brown pores. Fertile fruiting

Fig 345. Internal tissue of a sterile fruiting body (light brown to reddish colour) on birch.

bodies can be difficult to find as they quickly deteriorate once exposed. Spores from fertile fruiting bodies can cause infection by entering old cankers, branch stubs, or wounds.

DECAY: The incipient stage of decay is indicated by yellowish-white streaking or spotting of the wood. Advanced wood decay is characterized by alternating zones of white and light reddish-brown wood with dark zone lines throughout. After tree death, advanced decay will move into the sapwood.

DAMAGE:

Severe damage results from infections. A single sterile conk indicates there is extensive damage and it is assumed that 50 to 100% of the wood is decayed. Trees with conks should be considered hazardous.

SIMILAR DAMAGE:

Small sterile conks and decay characteristics of *Inonotus obliquus* are similar in appearance to those of *Phellinus ignarius*. Locating larger conks of either fungi on surrounding trees will assist in identification.

SOOTY BARK CANKER

Encoelia pruinosa (Ellis & Everh.) Torkelson & Eckblad
(=*Cenangium singulare*) (Rehm.) Davidson & Cash

DISTRIBUTION

Throughout the range of its host.

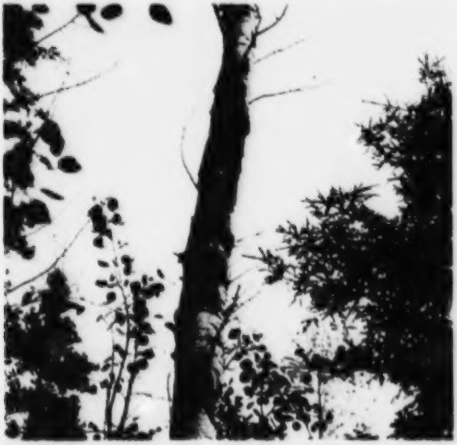


Fig 346. Elongated black cankers of Encoelia pruinosa *on mature trembling aspen.*

TREE SPECIES ATTACKED:

Trembling aspen is the major host. Black cottonwood and balsam poplar are occasionally attacked.

WHAT TO LOOK FOR:

Large black cankers on the stem up to several metres long. Small, grey, cup-shaped fruiting bodies in the cankered areas of dead trees. Dead bark that easily crumbles and resembles soot.

SIGNS & SYMPTOMS:

The fungus commonly attacks older, injured trees. Upon entering a wound, the fungus grows into the inner bark and cambium. A canker begins as a sunken oval with blackened inner bark. Its development is so rapid the tree cannot form defensive callus tissue. Cankers can expand in length 1 m in one year, reaching a final length of

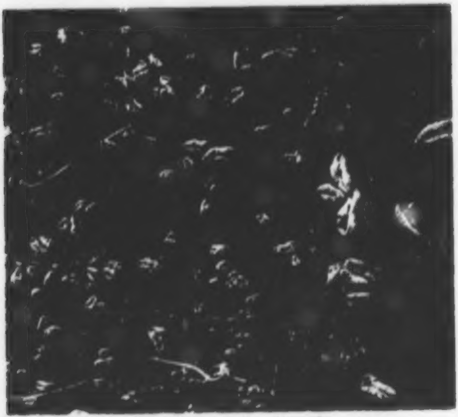


Fig 347. Grey, cup-shaped fruiting bodies of Encoelia pruinosa.

3 to 4 m. The outer bark will later slough off to expose the sooty, black, inner bark. After tree death, small (1 to 3 mm) grey, cup-shaped fruiting bodies are produced in blackened areas where bark has fallen off. The dead bark resembles soot as it crumbles in the hand. The disease is found primarily in trembling aspen stands that are mature or over 60 years old.

DAMAGE:

In northern and interior BC, *Encoelia pruinosa* is the most damaging primary canker pathogen of aspen.

CYTOSPORA CANKER

Valsa sordida Nitschke (anamorph = *Cytospora chrysosperma* (Pers.:Fr.) Fr.)

DISTRIBUTION

Widely distributed throughout its range of hosts.

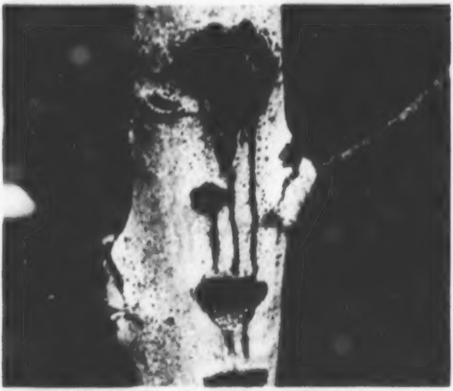


Fig 348. Canker caused by Valsa sordida on trembling aspen.

TREE SPECIES ATTACKED:

The major hosts are trembling aspen, black cottonwood, balsam poplar, and hybrid poplars.

WHAT TO LOOK FOR:

Black, sunken areas on stems, branches, and twigs. Short, grey-black cones that ooze orange-red, hair-like tendrils during damp conditions.

SIGNS & SYMPTOMS:

Elongated cankers with defined borders form on weakened stems. Branches and twigs can be colonized and killed without canker formation. Cankers first appear as sunken, discoloured zones with raised edges. The canker's inner bark progressively changes in colour from bright orange to black and can have a foul odour. After 2 to 3 years, the dead bark falls off the stem in large pieces. Sapwood associated with the canker is stained light to reddish-brown.

The asexual stage of the fungus *(C. chrysosperma)* produces fruiting bodies within the dead bark of the

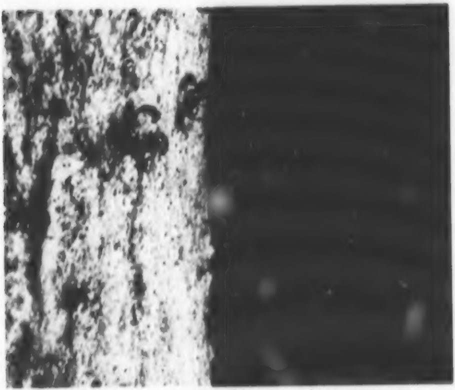


Fig 349. Orange-red spore tendrils of Cytospora chrysosperma on trembling aspen.

canker. The fruiting bodies are short, grey-black cones, 0.5 to 1 mm in diameter. Their presence gives the bark a pimpled appearance. Orange-red spores ooze out of the cones in long, coiled, hair-like tendrils (up to 10 cm long) during damp conditions. The sexual stage *(V. sordida)* produces flask-shaped, black structures that release masses of white spores, which collect at the flask base. The flasks form underneath the old cones and surround them in groups of 6 to 12. The asexual stage is more common than the sexual.

DAMAGE:

V. sordida is considered a weak parasite and its presence indicates trees are under stress. The fungus is an opportunistic, secondary pathogen that is more likely found colonizing recently dead tissues, as opposed to being the primary cause of tree mortality. In BC, *C. chrysosperma* is considered the most common opportunistic canker-inducing pathogen. Cytospora cankers do not occur on healthy, vigorous, undamaged trees.

FOLIAR DISEASES AND SHOOT BLIGHTS

Foliar diseases include leaf and shoot blights, and leaf rusts, blotches, and spots. Foliar infections occur most often during the spring months when leaves are new and succulent. If moist warm conditions prevail during the spring, infection rates and subsequent damage will be more prevalent. Disease symptoms range in severity from dark round leaf spots to whole leaves or shoots becoming blackened and shriveled. Defoliation is a very common indicator of foliar disease, but often the impact is minimal. When defoliation is severe over consecutive growing seasons, mortality or growth reductions can occur. Understory and younger trees are most at risk.

ASPEN AND POPLAR LEAF AND SHOOT BLIGHT

Venturia macularis (Fr.:Fr.) E. Muller & Arx. / *Venturia populina* (Vuill.). L. Fabricius

DISTRIBUTION

Widely distributed throughout the range of its hosts in BC. Venturia macularis is especially severe in northern BC.

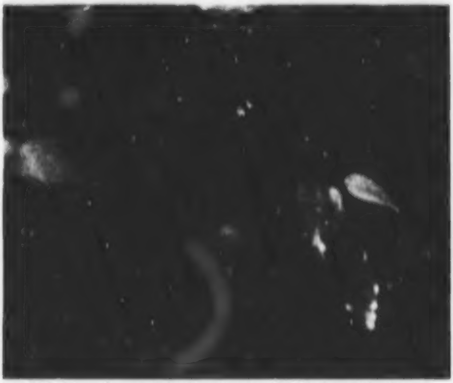


Fig 350. V. populina on hybrid poplar. Note the blackened dead tissue forming a sheperd's crook.

TREE SPECIES ATTACKED:

Venturia macularis attacks primarily trembling aspen. *Venturia populina* attacks balsam poplar, hybrid poplars, and black cottonwood.

WHAT TO LOOK FOR:

Blacken and wilted new tissues that resemble a shepherd's crook. Masses of olive-green spores on blackened dead tissue.

SIGNS & SYMPTOMS:

These fungi overwinter in sexual and asexual structures found on dead shoots, leaves, and blighted twigs. Spores are dispersed in the spring via wind and rain to infect newly formed shoots and leaves. The fungus first appears as black leaf spots. The spots will continue to spread down the leaves into succulent branchlets. The infected new shoots and leaves will turn black and wilt, resembling a shepherd's crook. A velvety mat of olive-green conidia (spores) are produced on the blackened, dead tissue. These spores are rain-dispersed and continue the infection on new leaves. Wet springs and summers are optimum conditions for infection.

Fig 351. Defoliation damage of aspen caused by Venturia spp.

DAMAGE:

Crowns are stunted and deformed when *Venturia* infections occur over successive years. During wet moist springs, *V. macularis* can kill most shoots in aspen stands regenerated by sprouting. *V. populina* has had a great impact on intensively managed hybrid poplar plantations. In damp, coastal hybrid plantations, cankers can develop and dieback areas are prone to breakage. Susceptible hybrid clones have been replaced with more resistant clones to reduce the impact of *V. populina*. Overall, wetter climates have the greatest infection rates and impact.

SIMILAR DAMAGE:

V. populina and *V. macularis* produce the same symptoms but on different tree species. Microscopically, they can be distinguished by their different-sized spores. Leaf spots caused by purple-brown leaf spot of aspen *(Pallaccia borealis)* are similar to those caused by *V. macularis*. However, *P. borealis* does not cause shoot dieback.

MARSSONINA LEAF BLIGHTS

Marssonina populi (Lib.) Magnus / *M. brunnea* (Ellis & Everh.) Magnus *f. sp. trepidae* Spiers / *M. brunnea* (Ellis & Everh.) Magnus *f. sp. brunnea* Spiers.

DISTRIBUTION

***Marssonina brunnea** has been found scattered throughout BC. **Marssonina populi** is restricted to the interior of BC.*

Fig 352. Leaf spots on hybrid poplar caused by Marssonina leaf blight (M. brunnea). Note the speckled appearance of the leaf.

TREE SPECIES ATTACKED:

Marssonina populi attacks black cottonwood and hybrid poplar. *M. brunnea f. sp. trepidae* attacks trembling aspen. *M. brunnea f. sp. brunnea* attacks hybrid (TxD) poplar clones.

WHAT TO LOOK FOR:

Dark, angular spots and coalescing necrotic areas on leaves. Orange-brown speckled leaves with masses of orange spores on the upper or lower surfaces.

SIGNS & SYMPTOMS:

In early summer, circular to angular brown spots (ranging in size from 1 to 5 mm) appear on the leaf surface. The spots may coalesce to produce larger necrotic patches. Necrotic areas caused by *M. populi* on some hybrid (TxD) poplar hosts are delimited only by leaf veins. Scabby areas are produced later when masses of orange conidia (spores) push through the leaf epidermis. *M. brunnea f. sp. trepidae* produces conidia mainly on lower leaf surfaces, *M. brunnea f. sp. brunnea* produces conidia on both the upper and lower surfaces, and *M. populi* produces conidia mainly on upper surfaces. A hand lens is required to detect the orange masses of conidia.

Fig 353. Further development of leaf spots on hybrid poplar caused by Marssonina leaf blight (M. populi). Note spots have coalesced to cover almost the entire leaf.

Macroscopically, leaves have an orange-brown speckled appearance. Wind or rain-dispersed conidia will continue spreading infection during the growing season. The fungus will overwinter on dead fallen leaves and shoot lesions. The various species of *Marssonina* are distinguished by spore size and shape and their host species.

DAMAGE:

Marssonina species can cause periodic, moderate defoliation of aspen and cottonwood. In the Prince Rupert region, *M. populi* causes heavy damage to cottonwoods. *M. brunnea f. sp. brunnea*, considered the most damaging Marssonina species affecting poplar, has been found on hybrid poplar in BC. Presently, recorded incidences are low, but the potential for future problems is great.

SIMILAR DAMAGE:

Early stages of leaf damage may be confused with *Septoria populicola* and *Linospora tetraspora*. Orange spore masses on the leaf surface produced later in the growing season will distinguish *Marssonina* spp. from *S. populicola* and *L. tetraspora*.

COTTONWOOD LEAF RUST

Melampsora occidentalis H. Jacks.

DISTRIBUTION

Widely distributed throughout the range of its hosts in BC.

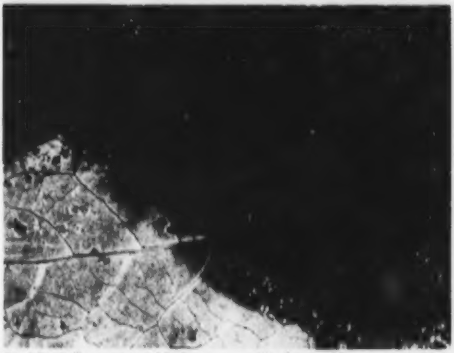


Fig 354. Yellow spots on black cottonwood leaf caused by cottonwood rust.

TREE SPECIES ATTACKED:

Black cottonwood, balsam poplar, and some hybrid poplars are attacked. Alternate conifer hosts include *Abies, Larix, Picea, Pinus, Pseudotsuga,* and *Tsuga* tree species.

WHAT TO LOOK FOR:

Orange spotted leaves with masses of yellow spores.

SIGNS & SYMPTOMS:

Stages of the life cycle are as follows: over-wintering spores on fallen poplar leaves infect conifer needles in early spring; spores produced on conifer needles then infect poplar leaves, and finally, new spores produced on poplar leaves infect new poplar foliage and promote the spread and intensity of the rust.

Infected poplar leaves are characterized by orange spots where masses of yellow powdery spores are released from pustules. Entire leaf surfaces can be yellow when infections are severe. Later in the summer, pustules are replaced with brown cushion-like structures. Leaf tissue surrounding infections often dies.

COTTONWOOD LEAF RUST

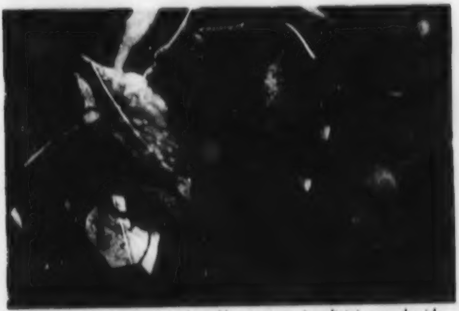


Fig 355. Cottonwood rust cushion-like structures (uredinia) on underside of black cottonwood leaf.

Damage:

Causes premature defoliation, and damage can be severe in susceptible trees. Reduction in diameter growth and development of root systems can occur in cottonwood, if repeated heavy infections occur early in the growing season. The majority of commercial hybrid poplars have been selected and genetically tested for resistance.

Similar Damage:

Melampsora medusae f. sp. deltoidae produces very similar symptoms. This *Melampsora* species has recently been introduced and is found in commercial hybrid poplar plantations in the Fraser Valley and Vancouver Island. Its conifer host is larch, but this stage of the life cycle has yet to be confirmed in BC. Microscopic examination of spores is required to distinguish between the two rusts.

Fig 356. Alternate host (Douglas-fir) infected with cottonwood rust.

LINOSPORA LEAF BLOTCH

Linospora tetraspora G.E. Thompson

DISTRIBUTION

North Vancouver Island, Fraser River, and mid-coast of BC.

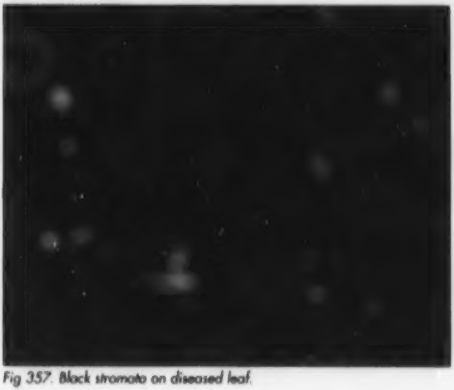


Fig 357. Black stromata on diseased leaf.

TREE SPECIES ATTACKED:

Black cottonwood, balsam poplar, and hybrid poplars are attacked.

WHAT TO LOOK FOR:

Large, irregular-shaped, brownish-grey blotches on leaves with feathery margins. Blotches with light brown centres and black rectangular spots (stromata).

SIGNS & SYMPTOMS:

Large, irregular-shaped, brownish-grey blotches appear along leaf veins. The margins of the blotches look feathery in appearance. The blotch centres later turn light brown with black, rectangular spots (0.5 mm). Entire leaves are often affected.

DAMAGE:

Native cottonwood in coastal plantations can be severely defoliated. In hybrid poplars, the lower canopy is most frequently attacked. Localized epidemics can cause significant economic losses in

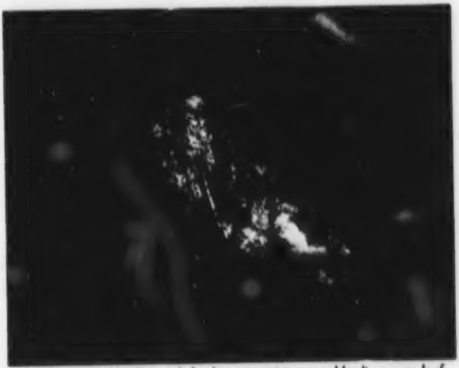


Fig 358. Brown blotches with feathery margins caused by linospora leaf blotch.

intensively managed broadleaf stands. Plantations in the Fraser River delta have had low to moderate foliar damage.

SIMILAR DAMAGE:

Early stages of leaf damage may be confused with *Septoria populicola* and *Marssonina* spp. A closer examination of the leaf blotch will identify the characteristic feathery margins, which distinguish *Linospora tetraspora* from the above foliar diseases.

SEPTORIA LEAF SPOT

Septoria populicola Peck
(teleomorph=*Mycosphaerella populicola* G.E. Thompson)

DISTRIBUTION

Fraser Valley and mid-coast river inlets of BC.

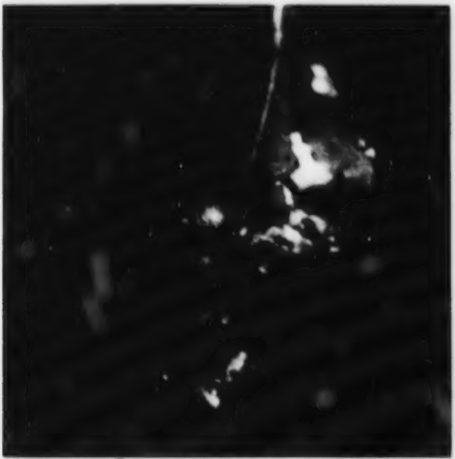


Fig 359. Round leaf spots on hybrid poplar caused by septoria leaf spot (Mycosphaerella populicola).

TREE SPECIES ATTACKED:

Black cottonwood, balsam poplar, and hybrid poplars are attacked.

WHAT TO LOOK FOR:

Round, yellow, or black lesions on discoloured (orange or yellow) leaves. Small, black fruiting bodies releasing pink spore tendrils.

SIGNS & SYMPTOMS:

Round, yellow lesions appear on the leaves. The lesions soon turn dark brown to black. In response to infection, leaves will turn orange or yellow. Small, black fruiting bodies are produced in the lesion areas, mainly on the upper leaf surfaces. The fruiting bodies release pink, hair-like strands of spores during wet weather. If wet weather conditions prevail, leaf infections will continue throughout the summer.

SEPTORIA LEAF SPOT

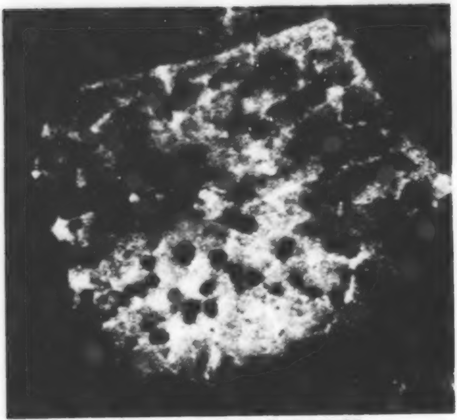


Fig 360. Septoria leaf spot fruiting body with spore tendrils.

The fungus overwinters on fallen diseased leaves. *Septoria populicola* is not associated with cankers in BC.

DAMAGE:

Can cause severe foliar discolouration and premature defoliation on black cottonwood. Hybrid poplars are affected to a lesser degree. As with other leaf spot diseases, *S. populicola* will not adversely affect tree health unless severe infections persist. Damage is normally minor in nature.

SIMILAR DAMAGE:

Early stages of leaf damage may be confused with *Linospora tetraspora* and *Marssonina* spp. Leaves turning orange or yellow and the presence of black fruiting bodies releasing pink spore tendrils will distinguish *S. populicola* from these other species.

ROOT DISEASES

Diseases of roots, root collars, or the butt include various species of armillaria root disease. Damage to broadleaf species by *Armillaria* is usually minor. In rare instances where mortality has occurred, the trees were previously stressed by other factors.

Heart rots present in the roots and butts of trees, such as *Ganoderma applanatum*, are included in the previous Heart Rot section.

ARMILLARIA ROOT DISEASES

Armillaria ostoyae (Romagnesi) Herink
A. sinapina (Bérubé and Dessureault) / *A. nabsnona* Volk and Burdsall

DISTRIBUTION

A. ostoyae *is present south of 52 to53° N (Prince George).*

A. sinapina *is present south of approximately 57° N (Fort Nelson).*

A. nabsnona *is present in coastal, southwestern BC.*

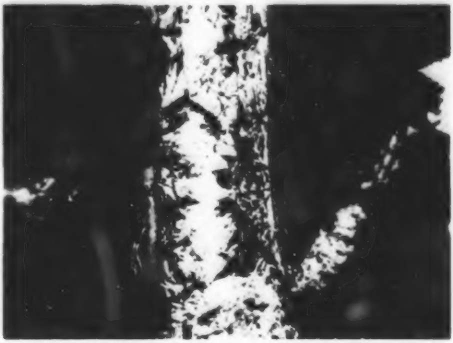


Fig 361. Mycelial fans of armillaria (A. sinapina) on trembling aspen.

TREE SPECIES ATTACKED:

Armillaria ostoyae is found on all species, but infrequently on trembling aspen in south-central BC. *A. sinapina* is found on all species. *A. nabsnona* is most frequently found on red alder, bigleaf maple, and less frequently on black cottonwood.

WHAT TO LOOK FOR:

Crown symptoms and mycelial fans at base of tree.

SIGNS & SYMPTOMS:

Crown symptoms include reduced top growth, premature defoliation, and leaf chlorosis. Trees can be affected either individually or in small groups defined as disease centres. Typically, centres include dead standing or fallen trees surrounded by dying trees.

White, fan-shaped mycelial felts are present under the bark at the base of the tree. Mycelial fans in aspen are extensive and may extend over 1 m. In cottonwoods, they are thinner and less prominent. Blackening of the bark and lesions up to 1 m in length also appear at the butt.

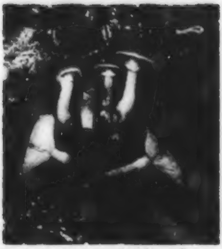


Fig 362. Young and old armillaria (A. sinapina) fruiting bodies. Note curved cap of younger fruiting bodies.

Fig 363. Aspen trees expressing crown symptoms caused by armillaria.

Black, shoe-string-like rhizomorphs are common on the roots, between the wood and bark and in surrounding soil. Rhizomorph widths range from 1 mm to 1 cm and can reach lengths of 1 m. *A. ostoyae* rhizomorphs are fewer in number and are branched in pairs. *A. sinapina* rhizomorphs are more abundant and branch in singlets off the main string. Rhizomorphs are rare in *A. nabsnona*-infected trees.

Fig 364. Young and old A. ostoyae fruiting bodies. Note curved cap of younger fruiting bodies.

FRUITING BODIES: Large clusters of mushrooms may appear on infected trees and stumps in late summer to mid–autumn. The mushrooms are cream to brown with a 5 to 10 cm wide cap and a conspicuous ring on the stem.

DECAY: In incipient (early) decay, wood is faintly water-soaked and then becomes light brown. In advanced decay, wood is light yellow or white and soft, spongy, and soggy.

Fig 365. Cross-sectional view of advanced armillaria decay on aspen.

DAMAGE:

Overall, damage to broadleaves by armillaria root diseases is minor. It rarely causes mortality unless the trees are under stress. There have been recorded incidences of reduced height and diameter growth, root decay, and reduced levels of suckering elsewhere in North America.

Introduction to Abiotic Damage of Broadleaf Trees

Injuries caused by abiotic (non-living) factors can cause damage to trees similar to that of insects, diseases, and animals. Five categories of similar abiotic injuries have been identified as economically significant to British Columbia's commercial broadleaf trees: wind; ice, snow, and hail; frost; wounds caused by fire, mechanical damage, or sunscald; and redheart. Abiotic injuries cause physical damage, but the main concern is the creation of points of entry for disease.

Abiotic injuries do not appear to be specific to any particular tree host, although some tree species have higher susceptibility. Topography and climate patterns certainly have an impact on tree susceptibility. Local knowledge of recent climatic extremes can be useful in identifying abiotic injuries. Abiotic injuries often cause greater damage to trees suffering from other damage agents or environmental stresses, and vice versa.

Other abiotic factors, such as excessive heat, drought, pollutants, salt, slimeflux, wetwood, erosion, recreation, flooding, and nutrient deficiencies, are not included in this field guide.

DISTRIBUTION

Throughout BC.

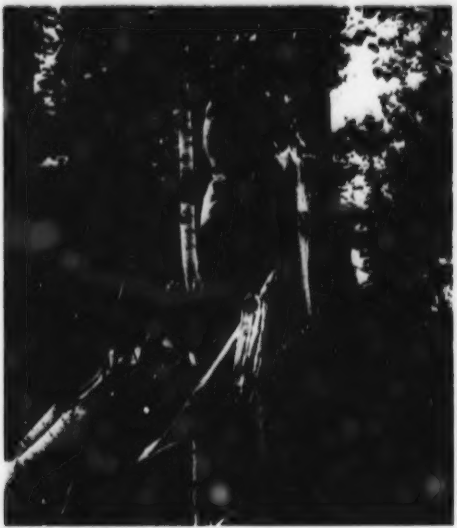


Fig 366. Wind damage to aspen.

TREE SPECIES ATTACKED:

All species can be damaged by strong winds.

WHAT TO LOOK FOR:

Toppled trees with root structure attached; broken branches mainly in the crown.

SIGNS & SYMPTOMS:

Strong winds can cause branches to break off or uproot the entire tree. Uprooted trees lay parallel, often with a large mass of roots and soil attached. Damage can be restricted to small areas or extended to larger areas. Susceptible trees are often diseased, along the margin of a harvested area, have shallow roots due to a high water table or shallow soils, or are stressed by other factors, such as poor drainage.

Fig 367. Wind damage to black cottonwood.

WIND

Fig 368. Trees snapped from wind.

Fig 369. Pattern of fallen trees from wind direction.

DAMAGE:

Periodic exposure to high winds can greatly reduce crown and stem quality and height growth. Tree mortality occurs when a tree is toppled. Trees subjected to continuous wind exposure, especially in higher elevations, are vulnerable to winter desiccation damage.

SIMILAR DAMAGE:

Trees that fall because of root rot, break at the root collar and lie in a criss-cross pattern in root–disease centres.

ICE / SNOW / HAIL

DISTRIBUTION

Throughout BC.

Fig 370. Tree has collapsed under weight of snow.

TREE SPECIES ATTACKED:

All species can be damaged by ice, hail, or heavy snow.

WHAT TO LOOK FOR:

Branches and main stems that are bent, broken, or deformed.

SIGNS & SYMPTOMS:

The weight of wet or heavy snow, or glazed ice such as freezing rain, on the foliage and branches of trees may result in bent or broken stems and main branches. Entire trees may bend over and break. After damage, the tree may grow disjointed, deformed stems. Trees with smaller diameter, in dense stands, or with stem or root diseases are most vulnerable. Snow accumulation and compression may cause basal decay or discolouration of seedlings. Hail damage symptoms consist of stripped branches, stem lesions, and scars and bruises on the upper surface of branches.

ICE / SNOW / HAIL

Fig 371. Snapped branch from weight of ice.

Damage:

Broken branches and stems may result in growth reduction and provide a court of entry for disease. Severe stem damage may result in mortality or broken leaders. Red alder, especially, is relatively brittle and very susceptible to breakage from ice, snow, or hail. Foliated trees may incur more damage.

Similar Damage:

Damage to branches by ungulates is restricted to the lower part of the tree.

Fig 372. Snow damage to aspen.

DISTRIBUTION

Throughout BC.

Fig 373. Black cottonwood leaves puckered from frost.

TREE SPECIES ATTACKED:

All species are susceptible to frost injury.

WHAT TO LOOK FOR:

Unhealthy appearance of foliage or buds; vertical cracks and cankers in bark.

SIGNS & SYMPTOMS:

Frost damage can occur in spring with a late frost, or in winter but with different effects. Spring frost affects new leaves and causes wilting, discolouration, puckering, and premature dropping of the young and succulent leaves. The foliage is patchy and not uniform when the trees foliate again after damage. Aspen and birch leaves may grow abnormally large. Older leaves can normally withstand frost despite marginal discolouration.

Fig 374. Frost canker.

Winter frost may cause stem and trunk damage in the form of cankers, cracks, and scabby (discoloured and scaly) bark. Damage most often occurs on the sun-exposed side of the tree. Cracks may be closed over by adjacent living bark, or may form cankers that bridge the wound with burls and ridges (frost ribs). On trunks, bulging frost cracks run vertically and start at wounds or branch stubs. The cambium can be cut between dead and live stem zones and examined for dark brown discolouration. Bud

Fig 375. Discoloured cambium from frost.

Fig 376. Frost crack on aspen.

damage causes central tissue mortality and reduced bud viability. Damaged terminal buds may produce forked stems or multiple-leaders. Frost damage to buds can be diagnosed by the discoloured, or green, and water-soaked appearance. Root collar damage causes cankers and girdling. Cankers may bridge over with new bark unless the tree is completely girdled.

DAMAGE:

Frost can cause tree mortality if the tree is girdled with cankers. Reduced growth from terminal bud damage and top damage can also occur. The main concern is the introduction of diseases through cracks and cankers. Cumulative effects of periodic frosts produce poor quality stands of red alder. Young or recently planted trees are most susceptible to damage. Low-lying depressions and slopes oriented towards the sun experience more severe frost. Frost cracks are especially common on large black cottonwood trees and other thin-barked trees.

SIMILAR DAMAGE:

Sunscald appears more as an elongated canker than a split in the bark.

Fig 377. Bud damage from frost.

WOUNDS: FIRE, MECHANICAL, SUNSCALD

(Also see *Frost* and *Animal Damage*)

DISTRIBUTION

Throughout BC.

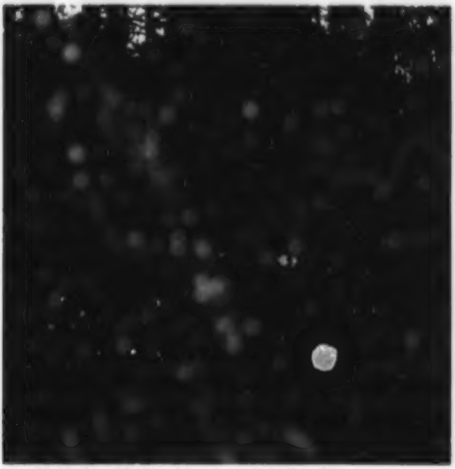


Fig 378. Blackened bark and crown symptoms from fire.

TREE SPECIES ATTACKED:

All species can be affected.

WHAT TO LOOK FOR:

Bark removal, gouges, cracks, cankers in the bark, or blackened carbon.

SIGNS & SYMPTOMS:

Open wounds of the bark and broken stems or branches may occur from several abiotic factors and by animals. Fire wounds are identified by charred and blackened bark. Mechanical wounds, typically caused by logging activities, are commonly found as gouges on the lower trunk. Sunscald is normally found on the southwest side of the trunk. Affected bark is initially copper to bright red but fades as the bark dies and sloughs off. Ground-level heat girdling of seedlings by the sun may also occur.

WOUNDS: FIRE, MECHANICAL, SUNSCALD

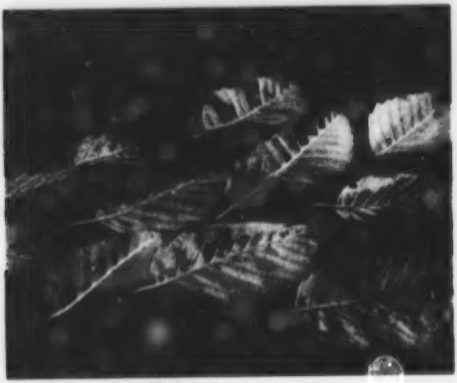


Fig 379. Sunscald on alder leaves.

DAMAGE:

Wounding itself causes little economic damage although severe sunscald, fire, or mechanical activities may cause enough cambial damage to cause tree mortality. Seedlings may die of heat girdling. The main concern is the creation of a point of entry for disease. Trees with thinner bark, such as cottonwood, are more susceptible to wounds.

SIMILAR DAMAGE:

The cause of the wound may become difficult to determine if a disease uses the wound as a point of entry for disease. However, in the early stages, wounding can be identified by examining the area around the wound for clues.

DISTRIBUTION

Coastal regions of BC for red alder and throughout the range of birch in BC.

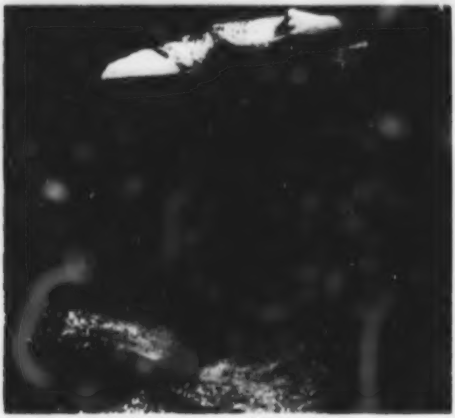


Fig 380. Longitudinal cross-section of redheart in alder tree.

TREE SPECIES ATTACKED:

Red alder and paper birch are susceptible.

WHAT TO LOOK FOR:

Reddish-brown stain in the centre of the tree.

SIGNS & SYMPTOMS:

Redheart refers to a reddish-brown stain found in the centre of red alder and paper birch trees. The staining is in stark contrast to the surrounding white wood and the discolouration is due to a chemical reaction.

The development of redheart has been shown to be associated with physical damage (scars, frost cracks, or broken tops) and the presence of fungi in the wood. In red alder, redheart has only been found where trees are environmentally stressed or are growing in off-site conditions.

Overmature and slow-growing paper birch have the greatest proportion of redheart.

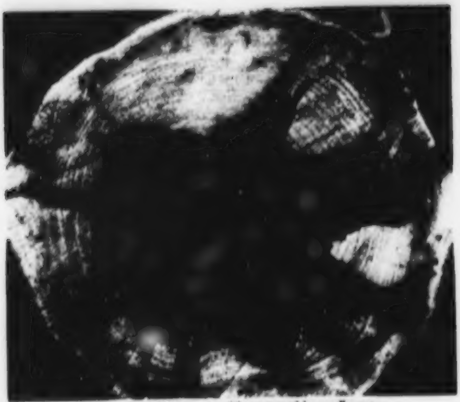
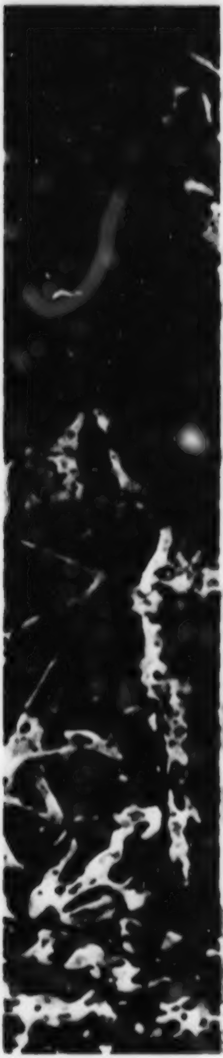


Fig 381. Cross-section of decay in alder caused by redheart.

DAMAGE:

Redheart reduces the economic value of the wood. In some areas of the BC mainland coast, more than 50% of the red alder crop trees are affected with redheart. Further research is required to determine the extent of damage and its distribution.



Introduction to Animal Damage of Broadleaf Trees

As animals forage and use trees to rub their velvet or hides, trees are often left damaged. Physical damage ranges from broken branches to uprooted seedlings.

Open wounds and stem deformities at branch stubs, and places where bark has been gnawed or rubbed off, create potential points of entry for disease. Most animal damage to trees is not widespread or severe enough to cause economic concern. However, voles, hares and rabbits, large ungulates (deer, elk and moose), beaver, and cattle have the ability to damage large numbers of trees. Other animals, such as the sapsucker, mountain beaver, bear, porcupine, caribou, squirrel, mouse, and goat do not appear to be of economic concern to foresters, but localized damage can be severe.

Recognition of animals as a source of damage in the field (as opposed to insect, disease, or abiotic damage) is the first step in identification. Scat, tracks, and other signs left by the animal near damaged trees will help to at least distinguish between rodent and ungulate, if not determine the species. Local knowledge of animal distribution and activity may also be an excellent source of information.

Although all tree species are susceptible to most kinds of animal damage, the animals themselves exhibit strong preferences while browsing.

DEER / ELK / MOOSE

Odocoileus spp. / *Cervus* spp. / *Alces alces* (Linnaeus)

DISTRIBUTION

White-tailed deer - southeast portion of BC.

Roosevelt elk - Vancouver Island, Sunshine Coast (re-introduced).

Rocky Mountain elk - throughout the Rockies and interior areas, and introduced on the Queen Charlotte Islands .

Moose, mule deer (and subspecies) - most of BC.

Fig 382. Moose damage to aspen. Note verticle teeth marks on bark.

TREE SPECIES ATTACKED:

All species are attacked, especially bigleaf maple, trembling aspen, and hybrid poplar.

WHAT TO LOOK FOR:

Patches of damaged bark, ragged browse patterns, stunted small trees, large droppings.

SIGNS & SYMPTOMS:

Ungulates damage trees in two main ways: by browsing seedlings, suckers, saplings, and foliage; and by rubbing antlers on saplings and larger trees. Browsing normally occurs in late summer and autumn, and in winter where deer or elk concentrate. Browsed trees produce more stems that are concentrated and stunted in appearance due to repeated terminal and lateral shoot removal. Ungulate browsing appears ragged and splintered as a result of pulling and gnawing with the teeth; seedlings may be inadvertently uprooted or have their tops broken off. Bark may also be removed with lower incisors, leaving vertical grooves on the trunk and branches. Tooth marks are approximately 4 mm (deer), 6 mm (elk), or 6 to 9 mm wide (moose).

Bark is worn by antler rubbing in late summer and autumn and can appear shredded, hanging in strips from the tree. Broken branches also indicate antler rubbing. Ungulates also trample young seedlings.

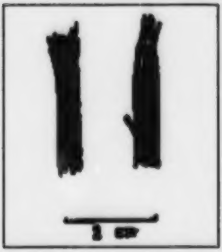


Fig 383. Square, ragged ends of shoots characteristic of deer, elk, and moose.

Fig 384. Moose damage to birch.

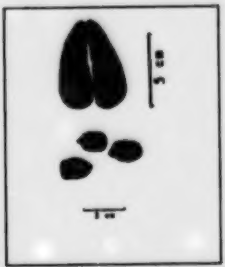


Fig 385. Deer tracks and droppings.

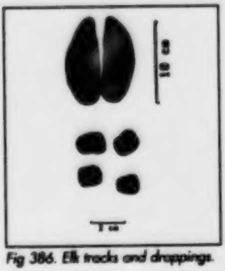


Fig 386. Elk tracks and droppings.

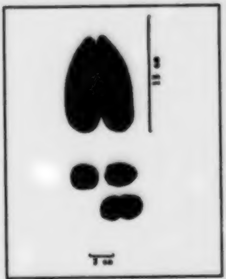


Fig 387. Moose tracks and droppings.

To determine the source of the damage, signs of the ungulate such as droppings and prints may be located near the damaged tree. Moose damage may reach higher up the tree than deer or elk. Moose are known to pull down trees of 3 m or greater and snap the top off while browsing. Local knowledge of mammal populations may also assist in identifying the source of damage.

DAMAGE:

Effects on young trees include decreased growth, stem deformation, and multiple stems. Open wounds provide entry sites for decay. Regenerating areas, widely-spaced plantations, and areas of high ungulate populations, risk permanent damage. Moose are known to decimate 1 or 2-year-old sucker stands by browsing tops and leaving only a few feet of the sucker behind.

SIMILAR DAMAGE:

Voles, rabbits, and hares also gnaw on the bark of trees; however, the teeth marks in the cambium are tiny (about 1.5 to 2 mm wide) and not uniformly vertical. Rodents and rabbits cleanly clip branches, whereas ungulates leave a ragged edge. Cattle damage can appear similar, but cattle droppings and prints can be distinguished from wild ungulates.

CATTLE

Bos taurus (Linnaeus)

DISTRIBUTION

Throughout BC, but mostly south-central BC.

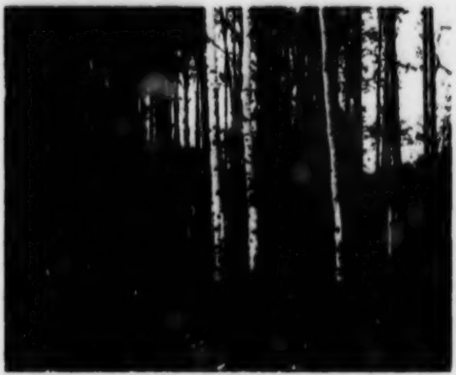


Fig 388. Damage caused by cattle rubbing. Note sparse understory from grazing, trampling, and soil compaction.

TREE SPECIES ATTACKED:

All species can be damaged by cattle.

WHAT TO LOOK FOR:

Uniformly scarred trunks, signs of grazing and trampling, hoof marks, droppings.

SIGNS & SYMPTOMS:

Cattle may trample and graze aspen suckers and regenerating areas. Grazing can result in the uprooting of seedlings. Aspen trunks can be wounded from rubbing. Soil may be compacted and show the imprints left by hooves. Understory growth may be sparse and annual plants replaced by perennials. Cattle droppings are unlikely to be confused with those of wild ungulates.

DAMAGE:

The greatest potential risk is the wounding of young aspen. This creates entry points for disease and may lower the wood quality and value. Over-grazing can limit regeneration and growth, and exhaust the root carbohydrate reserves. Light grazing can cause growth too dense for commercial use. Seedlings and saplings are most susceptible to mortality.

SIMILAR DAMAGE:

Cattle damage and wild ungulate damage are very similar. To distinguish between them, look for signs left by the animals, like hoof prints and droppings.

SNOWSHOE HARE / COTTONTAIL RABBIT

Lepus americanus (Erxleben) / *Sylvilagus* spp.

DISTRIBUTION

The snowshoe hare is found throughout BC, except in the north coastal area and coastal islands. The cottontail rabbit is distributed in the south-central portion of BC.

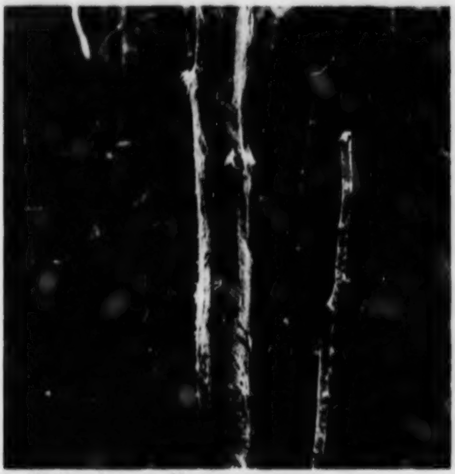


Fig 389. Hare damage to alder. Note ragged appearance.

TREE SPECIES ATTACKED:

Black cottonwood, paper birch, trembling aspen, and balsam poplar are damaged by hares and rabbits.

WHAT TO LOOK FOR:

Ragged patches of gnawed bark around the base of the tree, cleanly clipped branches, droppings.

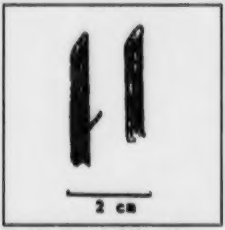


Fig 390. Sheer, knifelike, oblique cut characteristic of hares, rabbits, pikas, and rodents.

SIGNS & SYMPTOMS:

Hares and rabbits clip twigs and buds with a clean, oblique cut, and girdle stem bases by gnawing on the bark. Shoots are normally missing. Twigs and seedlings become stunted and dense over time. Gnawed bark is ragged and shows indistinct teeth marks with an average width of 2 mm. The resin of balsam poplar repels snowshoe hares. Foliar buds have higher resin content than internodes and are avoided, but internodes are browsed. In winter, snowshoe hare damage occurs above the surface of

Fig 391. Winter damage appearing higher up the stem then expected.

the snow. This winter feeding then appears higher up the tree than expected in snowless months.

The snowshoe hare is the most common of the species in BC and its population is known to cycle every 9 to 10 years. Browsing damage is most severe in peak population years. The year 2000 is expected to be a peak year.

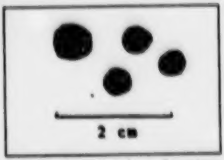


Fig 392. Snowshoe hare droppings.

Damage:

Tree mortality may occur with girdling. Growth reduction may be severe on seedlings. Stem deformation may lend to reduced values of wood.

Similar Damage:

Hare and rabbit damage can be confused with rodent damage. Voles use many cuts to sever a stem, not just one, and leave smaller droppings. Squirrels will leave cut stems and bark at the base of the tree. Damage caused by the mountain beaver, which occurs in BC only on the coast adjacent to the American border, can be mistaken for hare or rabbit damage. Contact wildlife specialists or local forest district staff for more information on mountain beaver damage.

VOLES

Microtus spp. / *Clethrionomys gapperi* (Vigors)

DISTRIBUTION

Throughout BC, except for the Queen Charlotte Islands.

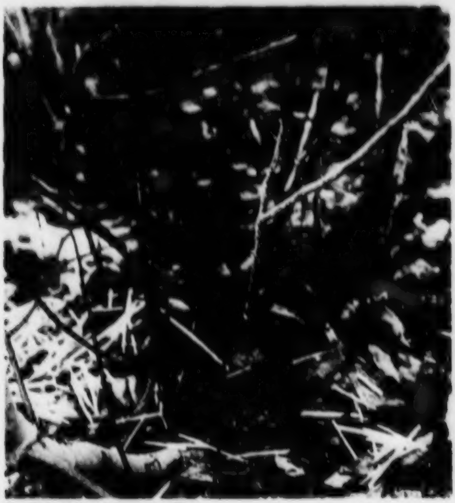


Fig 393. Vole damage to willow.

TREE SPECIES ATTACKED:

Trembling aspen, black cottonwood, hybrid poplar, and sometimes red alder are damaged by voles.

WHAT TO LOOK FOR

Fuzzy patches of gnawed bark around the base of the tree, clipping by several cuts, runways, and droppings.

SIGNS AND SYMPTOMS

Terminal and lateral shoots of small seedlings are severed by many cuts, leaving a rough cut. Gnawing of bark on the roots, root collar, low branches, and stem result in fuzzy exposed sapwood. Girdling by gnawing bark of young stems or suckers below the root collar in plantations is common in grassy and wet areas. In winter, girdling can occur above or below the snow level. Voles may gnaw off young

Fig 394. Apple tree girdled by vole.

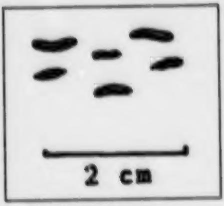


Fig 395. Vole droppings.

seedlings and remove them from the site. Gnawing and girdling activities occur mainly during winter and early spring.

Girdling can be examined by brushing the duff and soil from around the damaged tree. Runway systems and tunnels can also be observed this way. Also look for small piles of grass clippings and droppings along runways.

Damage:

Girdling leads to tree mortality. Damage is greater in years of high populations (every 3 to 4 years). Heavy losses can occur in black cottonwood and hybrid poplar plantations. Voles create the largest potential impediment to plantation establishment for native cottonwoods and hybrid poplars. Vole damage can occur on trees 10 to 12 m tall.

Similar Damage:

Rabbits or hares make a single, clean, oblique cut to stems and branches and leave teeth marks on gnawed bark.

BEAVER

Castor canadensis Kuhl

DISTRIBUTION

Throughout BC.

Fig 396. Beaver damage to aspen.

TREE SPECIES ATTACKED:

All species can be damaged by beaver, especially trembling aspen, black cottonwood, balsam poplar, paper birch, and hybrid poplar.

WHAT TO LOOK FOR:

Deep gnawing at base of main stem, often falling the tree.

SIGNS & SYMPTOMS:

Beavers fall trees to supply their dam construction activities. They often flood forested areas for several years or decades. The remaining stumps are easily identified as beaver damage by their pencil-tip shape and teeth marks in the exposed wood. Wood shavings around the base of the stump may be found, along with trampled paths leading to water.

Beavers clip seedlings, saplings, and branches from felled trees as food sources, especially in autumn. The clean, diagonal cut is diagnostic of beaver damage. Some branches may be cleanly stripped of bark. Broadleaf trees are preferred as food,

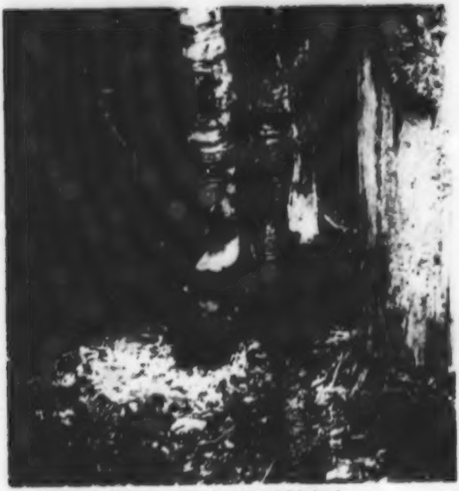


Fig 397. Beaver damage. Note wood chips left behind.

especially smaller poplars and aspen, but almost any tree species of any size, including conifers, will be used, especially when located close to their lodge.

DAMAGE:

Tree and seedling mortality occurs from felling and flooding. Damage may be extensive near beaver dams and lodges. Beavers rely heavily on aspen for food and dam construction material; about 200 aspen trees would support one beaver for one year. Beavers can cause extensive mortality of saplings and trees up to 200 m from streams. Hybrid poplar plantations are know to incur heavy losses as whips and young trees are chewed off.

SIMILAR DAMAGE:

Tree damage by beavers is highly diagnostic and the risk of confusion with any other damage should be low.

USING THE HOST-AGENT INDEX

Only damage agents or abiotic factors discussed in this field guide are included. The host-agent index should be used together with the pictures and descriptive text of this guide. The host-agent index indicates particular damaging agents that could be found on certain areas of the host.

Host common names are listed in alphabetical order in the host-agent index. Each host is then subdivided into the following sections: branch tips or leaders, foliage, main stem or branches, and roots or collar. Insects, diseases, abiotic agents, and animals are alphabetically listed by common name under the relevant section(s), depending on where the most specific sights and symptoms initially appear. This arrangement facilitates identification, since many damaging agents cause non-specific symptoms to other portions of the host. For example, most root disease organisms cause a general chlorosis of the crown. However, certain insect species and animal agents also produce this symptom. The species responsible for this chlorosis can only be determined by examining the roots and/or root collar where specific signs and symptoms can be seen. Thus, root diseases are listed under the roots or root collar section of each host in this index, despite damage to the crown.

Young tree woody tissue feeders and animal species are placed under the section on branch tips or leaders. Defoliators; some species of sucking insects; and needle casts, blights, and rusts are listed under the foliage section. Certain woody tissue feeders, sucking insects, and animal species, as well as broom rusts, dwarf mistletoes, and branch/stem cankers and diebacks are found under the main stem or branches section. Abiotic factors and many animal species often cause direct damage to more than one area of a tree, and are listed accordingly. Page numbers beside each agent direct the reader back to the descriptive text and photographs for tentative confirmation. Suitable specimens of uncertain identity can be collected and shipped for final identification according to the specimen collection and shipment section, which follows this host-agent index.

HOST-AGENT INDEX

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SPECIMEN COLLECTION AND SHIPMENT

Collection and identification of forest insects and fungi are essential for effective forest management. Legal, scientific, and historical benefits of expert identification and archiving include records for quarantine and regulatory issues, substantiation of current outbreaks and previously undetected agents, and documentation of research results.

SPECIMENS ACCEPTED:

Please submit only the following types of specimens:

- insects, diseases, and fungi from forest habitats or wood products (not from agricultural, garden or ornamental plants, or stored products)
- agents causing new or major outbreaks
- materials to document special studies, surveys, research, and publications
- samples of unusually severe damage by known or unknown factors, for future reference

Identification of samples in the field by contractors can only be done with the prior permission of Ministry regional or district staff.

REPORT INFORMATION:

All specimens sent to the Canadian Forest Service (CFS) must include a FS 466 form (available from Forest Region offices) or equivalent, with the following minimum data (letters correspond to those on front of the FS 466):

A Geographic location of collection (reference the collection location to a recognized locality on 1:100 000 or 1:250 000 map sheet), and either UTM grid or latitude/longitude.

B Date of collection (year-month-day, e.g., 99 06 04).

C Name, affiliation, mailing address, telephone and fax numbers, and e-mail address of the collector.

If the individual requesting identification is not the collector, give the name, affiliation, mailing address, telephone and fax numbers, and e-mail address of the requester under "Remarks."

D Host-substrate information (host species, age, condition, number of hosts similarly affected, location of damage on host, or type of substrate, if not a plant).

E Description of area (e.g., non-forest, natural forest, plantation, bog, urban).

F Damage intensity and occurrence.

G Note unusual conditions/contributing factors, e.g., heavy frost, drought, chemical applications, proximity to roads, etc. Attach extra sheet if needed for remarks.

SPECIMENS AND SHIPMENT

Special care must be taken to collect an adequate specimen and to prevent deterioration of material in transit. Inadequate or spoiled material cannot be processed. Ship live material by Priority Post or courier, and use crush-resistant containers (e.g., mailing tins). For labels on vials, notes, and enclosures, use HB pencil or India ink to ensure permanency. ***NEVER USE PLASTIC BAGS OR WRAP,*** except for shipping defoliating insects, and do not moisten specimens. For fresh disease or fleshy fungi collections, prevent mould contamination by using paper envelopes, paper wrapping, and cardboard boxes for shipping.

- **Larvae of defoliators:** Ship 10 to 20 live larvae in a tied plastic bag with sufficient foliage for 3 to 5 days of feeding. Ship additional larvae in small screw-top vials containing 70 to 80% ethanol (preferred) or isopropyl (rubbing) alcohol. Vials must be well-sealed and packaged with sufficient absorbent material and a waterproof wrap to prevent contamination or leakage if a container should break.

- **Larvae of bark beetles or woodborers:** Collect borers in small-diameter (<10 cm) stems or shoots. Ship larvae from larger material in alcohol as above. Enclose a sample of typical damage, packaged separately.

- **Pupae and hard-bodied insects:** Ship live material in small containers with packing to protect during shipping. Place dead adult specimens between layers of tissue paper (no cotton) in a rigid container with sufficient packing to prevent any movement of material within the container.

- **Foliar diseases:** Collect 20 cm-length branches with leaves. Press flat between newsprint or, for bushy specimens, wrap in a paper bag. Include a cutting of healthy foliage (labelled) for comparison, and flowers or fruit of host plant, if the identity is unknown. For spring collections, include over-wintered, old foliage from ground litter or tree for possible mature fruiting bodies.

- **Stem and branch diseases:** For small-diameter material, cut a 20 cm-length of affected and adjacent healthy stem material. For larger material, cut a section of at least 10 x 10 cm from the edge of a canker. Include affected and healthy-appearing tissue. Include a section of bark with any apparent fruiting bodies.

- **Decay in wood, root disease, and blowdown trees:** Determine tree species. Collect any conk or mushrooms closely associated with decay. At any fungal conks, areas of breakage or suspect decay, including decayed or diseased roots, cut a wood section of at least 15 x 15 cm that includes decayed, stained, and apparently sound wood. Describe decay. For suspect root disease, select trees that were recently killed, fallen, or declining (symptomatic), and avoid trees or roots that have been dead for one or more years. Sample fresh roots with disease features such as pitching, mycelia, and/or stain. Package wood samples and conks separately. Label and wrap in newsprint.

- **Fleshy Fungi:** Collect several specimens, especially of varying maturity. For ground specimens, pry as much of the mushroom as possible out of the ground with a knife. For specimens on wood, also collect a specimen of any underlying wood decay, as described above. Dry all fleshy fungi before shipping. Air-dry small fragile specimens in a warm, dry place, and for larger fungi, heat-dry at 50°C. Spore prints from fresh collections can be submitted with dried specimens. Package in dry material to protect in transit.

Send specimens with the white copy of the *Forest Insect and Disease Collection and Identification* form (FS 466) to one of the following:

Canadian Forest Service
Pacific Forestry Centre
506 West Burnside Road
Victoria, BC, V8Z 1M5
Attention: Insectary/Herbarium
Tel: 250-363-0600
Fax: 250-363-0775

Forest Resources Manager
Cariboo Forest Region
200 640 Borland St.
Williams Lake, BC, V2G 4T1

Entomologist / Pathologist
Kamloops Forest Region
515 Columbia St.
Kamloops, BC, V2C 2T7

Entomologist / Pathologist
Nelson Forest Region
518 Lake St.
Nelson, BC, V1L 4C6

Entomologist / Pathologist
Prince George Forest Region
1011 4th Ave.
Prince George, BC, V2L 3H9

Entomologist / Pathologist
Prince Rupert Forest Region
Bag 5000, 3726 Alfred Ave.
Smithers, BC, V0J2N0

Entomologist / Pathologist
Vancouver Forest Region
2100 Labieux Rd.
Nanaimo, BC, V9T 6E9

GLOSSARY

ABDOMEN - Posterior part of an insect's main body divisions.

ABIOTIC - Non-living.

ADVENTITIOUS - Arising in other than the usual location.

AERIAL SHOOT - Stem-like portion of a dwarf mistletoe parasitic plant that is outside the host bark. This portion produces sticky seeds.

ALTERNATE HOST - One of two or more different hosts required by an insect, fungus, or other organism to complete its life cycle.

ANNUAL - A plant for which the entire life cycle is completed in a single growing season.

APOTHECIA - Open or cup-shaped fruiting bodies, produced by certain ascomycete fungi, with the spore containing sacs on the inner surface.

BASAL CUP - The cup-like remnant of a dwarf mistletoe infection remaining on the bark long after the disintegration of an aerial shoot.

BWBS - Boreal White and Black Spruce biogeoclimatic zone.

BLIGHT - The sudden dying of shoots or foliage due to infection by certain species of blight fungi (or, rarely, by other microorganisms). Usually results from repeated infections throughout the summer. Several years of tissue growth are often infected.

CAMBIUM - The actively dividing layer of cells which produces the conducting tissue of a vascular plant, therefore increasing the girth of a stem, branch, or trunk.

CANKER - Dead portion of the cambium and bark on a branch or the main stem. Cankers can be raised or sunken, and are sometimes surrounded by a raised lip of tissue.

CASE - The hollowed-out and silk-lined portion of a needle used as a protective covering by the larch casebearer.

CHLOROSIS - The yellowing of normally green foliage tissue due to lack of chlorophyll.

COCOON - Silken case spun by an insect larva inside which the pupa is formed.

CONDUCTIVE TISSUE - Refers to the xylem and/or phloem tissue of vascular plants through which the products of photosynthesis, water, and nutrients are conducted.

CONK - The fruiting body of a wood decay fungus; bracket-like or resupinate, but not a mushroom. Usually woody or leathery in texture.

CWH - Coastal Western Hemlock biogeoclimatic zone.

DECAY - The gradual disintegration of plant tissue due to extra cellular enzymes produced by fungi and other microorganisms.

DIEBACK - The progressive dying from the tips downward or inward of shoots, twigs, tops, branches, or roots.

DISTAL - Near or toward the free end of an appendage; that part of an appendage farthest from the body.

DISTRESS CROP - A crop of small cones produced by a tree under conditions of severe stress.

ECTOTROPHIC - Growing on the outside or surface.

ELYTRA - The hardened, often leathery, forewings of beetles, which cover the membranous hind wings when the insect is not in flight.

ENDEMIC - A disease, insect, or vertebrate animal that is native to a particular area. Often refers to the level of incidence or population numbers that are believed to occur in a native population.

EPIDEMIC - A widespread and unusually high level of incidence of a disease or insect pest; generally preceded by a rapid increase in population size.

EPIDERMIS - The outer tissue layer of leaves, young stems, or roots.

FASCICLE - A bundle or group or needles arising from one bud on coniferous species, usually pines or larches.

FIVE-NEEDLED PINES - Pine species that have needles arranged in fascicles or bundles of five. Sometimes referred to as soft pines.

FLAGGING - Conspicuous dead shoots or branches with foliage still present, but discoloured.

GLOSSARY

FRASS - Solid excrement of insects.

FRUITING BODY (or FRUITING STRUCTURE) - The reproductive structure of a fungus that produces spores.

FUNGUS (pl. FUNGI) - A diverse group of heterotrophic organisms that usually reproduce by spores and are composed of cellular filaments (hyphae). Most tree diseases are caused by fungi.

GALL - An abnormal growth of plant tissue seen as a swelling on the branches or main stem, and caused by fungal or insect activity.

HEART ROT - any rot characteristically confined to the heartwood.

HIP CANKER - A canker-like lesion with a flattened face and bulging sides on the main stem of a tree, usually resulting from western gall rust.

HYPHA (pl. HYPHAE) - A fine, usually branched, threadlike filament of the vegetative body of a fungus that grows on, or within a host. A mass of hyphae is termed mycelium.

ICH - Interior Cedar-Hemlock biogeoclimatic zone.

IDF - Interior Douglas-fir biogeoclimatic zone.

INCIPIENT - An early, less noticeable, or hidden stage in the progression of a disease or disorder.

INCISOR - A tooth adapted for cutting.

INFECTION - The process or interaction that follows entry of an organism or virus into a host; the establishment of a pathogenic or parasitic relationship.

INSOLATION - Solar radiation as received by the earth.

INSTAR - A stage in the development of an insect larva between periods when the larva sheds its skin in order to grow.

INTERNAL RADIAL SHAKE - The internal radial cracking of wood due to expansion and contraction as a result of frost.

LAMINATED - Separated into layers or sheets, particularly along the annual rings.

LARVA (pl. LARVAE) - An immature form of an insect that undergoes complete metamorphosis.

LESION - A localized area of dead or diseased tissue.

LION'S TAIL - With respect to needle diseases, a severe infection resulting in so much needle casting that only the current needles remain on the branchlets, thus creating a tufted appearance.

LOOPER - Larval stage of some moths that have some of the abdominal legs missing, thus causing the back to arch when moving.

MYCELIUM (pl. MYCELIA) - The vegetative feeding structure of a fungus, composed of interwoven hyphae, and considered distinct from the fruiting body.

NECROSIS (NECROTIC) - Death of cells or tissues which are still part of a living organism.

NEEDLE CAST - Premature dropping of needles due to attack by certain needle cast fungi, or occasionally caused by non-infectious organisms. Often only one year's growth is infected. Usually results from infection by ascospores in the spring.

NUTRIENT - An element required to maintain health and normal growth.

NYMPH - Immature stage of an insect which undergoes incomplete metamorphosis; resembles the adult, except for incomplete gonad and wing development.

PATHOGEN - A living organism that incites disease in a host.

PERENNIAL - A woody or herbaceous plant that lives from year to year .

PEST - An organism on a particular site that is determined to be damaging or interfering with resource management objectives.

PHLOEM - One of the conducting tissues of vascular plants through which products of photosynthesis are transported; located adjacent to the cambium or inner bark.

PP - Ponderosa Pine biogeoclimatic zone.

PRIMARY HOST - The organism on which the first two spore stages of a rust fungus exist.

PROXIMAL - That part of an appendage closest to the body.

PUPA (pl. PUPAE) - The inactive transitional stage in insects between the larva and adult portions of the life cycle. This stage is characterized by a protective covering formed by a larva during pupation.

PUPATION - Transition of an insect larva into a pupa and within the pupa.

PUSTULE - An immature fruiting body on the host exterior, either button-like or blistered in appearance.

RESINOSIS - An abnormal flow of resin or pitch from a conifer, often in response to infection, insect activity, or wounding.

RESISTANT - The ability to withstand attack by pathogens or insects.

RESUPINATE - A fruiting body that is reclined or flat on the host or ground.

RHIZOMORPH - A dark, hardened, cordlike structure made of hyphae, occurring in some fungi, such as *Armillaria* spp.

ROOT BALL - A characteristic clump or wad of roots that has rotted off close to the root collar; often seen in toppled trees with root disease.

ROT - A state of wood decay which is usually obvious and is generally caused by fungal attack.

RUST - A disease caused by a rust fungus, often manifested by orange to red spores at some point during the infection.

SAPROPHYTIC - The action of an organism feeding on dead organic material, usually by decomposing and adsorbing it and assisting in its decay.

SBS - Subboreal Spruce biogeoclimatic zone.

SECONDARY ATTACK - Attack by those organisms which only invade hosts predisposed by stress or attack by more virulent or aggressive organisms.

SENESCENCE - The process of decline associated with aging.

SETAE - Stiff hairs or bristles.

SIGN - Visible portion of a fungus or insect, such as a conk or frass, seen on, in, or around the host.

SHEPHERD'S CROOK - Bending of a tree leader or branch tip to form an inverted j-shape, often an indicator of fungal or weevil attack.

SPIKE-TOP - The dead portion of the upper crown, or a dead leader devoid of foliage.

SPORE - A microscopic reproductive structure of fungi consisting of one or more cells.

SPOROPHORE - The fruiting body of a fungus that produces spores; for example, conk or mushroom.

SYMPTOM - Visible reaction of a host to abiotic injuries or disease; for example, chlorosis.

TARGET CANKER - A perennial canker distinguished by concentrically arranged zones of callus which mark alternate outgrowth and death of the edge of living tissues surrounding the wound.

TxD - An acronym referring to hybrid poplar clones composed of *Poplus trichocarpa* and *P. deltoides* parents.

TUSSOCK - A brush-like protruding bundle of hairs. Seen especially on Douglas-fir tussock moth larvae.

TWO OR THREE-NEEDLED PINES - Pine species that have the needles arranged in bundles of two or three. Sometimes loosely referred to as hard pines.

VECTOR - Any living or non-living agent that can carry a pathogen from one host to another.

WEEVIL - A beetle of the family *Curculionidae*, characterized by a head prolonged into a beak or snout and bearing clubbed, elbowed antennae.

WITCHES' BROOM - Abnormal proliferation of shoots and branches, usually induced by dwarf mistletoe, rust fungi, or other organisms, but sometimes in response to abiotic agents or genetic abnormalities of the host tree.

XYLEM - The principal strengthening and water conducting tissue in plants.

ZONE LINE - Narrow brown to black lines in decayed wood formed by fungi to resist invasion by other fungal species.

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